EXPLORING THE USE OF VISUAL AIDS IN TEACHING GRADE 7 GEOMETRY TO ENHANCE THE LEARNING EXPERIENCE

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DECLARATION

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I hereby declare that the dissertation titled EXPLORING THE USE OF VISUAL AIDS IN TEACHING GRADE 7 GEOMETRY TO ENHANCE THE LEARNING EXPERIENCE is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references. Further, I declare that I have submitted the dissertation to originality checking software and that it falls within the accepted requirements for originality. I declare that I have not previously submitted this work, or part of it, for examination at UNISA for another qualification or at any other higher education institution.

______________ 23/04/2026

Signature Date

DEDICATION

I dedicate this research study to my parents, for their constant encouragement and steadfast belief in my abilities.

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ABSTRACT

This study addresses the use of visual aids in teaching geometry to enhance learners' learning experience. This qualitative phenomenological study draws from Duval's theory of semiotic representation which emphasises the alignment of symbolic, iconic and indexical representations in the connection of abstract mathematical concepts with practical and concrete learning experiences. Through purposive sampling, six teachers teaching Grade 7 mathematics were sampled and engaged in semi-structured interviews. Classroom observations were conducted to explore the teachers' interaction with learners in their respective classrooms. This study shows that using semiotic representations in geometry supports learners' interest and engagement, which in turn improves their understanding. This explains that the use of visual aids in teaching geometry impacts on the semiotic registers, that is, the visual, symbolic and verbal registers to enhance geometric cognitive understanding and knowledge retention. In addition, the findings show that visual aids help make abstract concepts tangible and support the development of deductive reasoning as a skill necessary for geometric problem-solving. The current study emphasise that the effective use of visual aids requires educators to align visual aids with curriculum goals, apply multi-representational strategies and differentiate instruction. Visual aids also promote equity by improving learners' access to learning. Essentially, using visual aids to teach geometry leads to inclusive, and mind-emancipating experiences with far-reaching implications for pedagogy and education equity. In this study, recommendations emphasise practical and collaborative ways to improve the teaching of geometry using visual aids in South Africa, especially in under-resourced schools. Educators should use creative, low-cost materials and adapt visual aids to meet different learner needs in extreme cases where there is lack of resources. Schools should develop shared resource systems and build partnerships to access basic teaching tools. Thus, a combined effort by schools, education authorities, communities and the private sector is needed to improve resource access, promote equity towards effective teaching and meaningful learning in mathematics classrooms.

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ACRONYMS AND ABBREVIATION

CAPS	Curriculum and Assessment Policy Statement
STEM	Science, Technology, Engineering and Mathematics
DLB	Display Light Board
2D	Two-Dimensional
3D	Three-Dimensional

CHAPTER 1

STUDY OVERVIEW

1.1 INTRODUCTION

The teaching of geometry is fundamental to learners' abilities towards cultivating logical thinking as articulated by the Van Hiele levels of geometric thought. Because these levels of geometric knowledge and understanding require students to transition from basic visualization to rigorous deduction in logical thinking, teaching strategies remain critical. That is, content delivery alignment with effective teaching strategies and resources is essential to enable learners' skills in practical applications of geometric content towards problem-solving (Alex & Mammen, 2018; Bansilal & Ubah, 2019; Grigaliūnienė et al., 2025; Mukuka & Alex, 2024; Saralar-Aras & Birgili, 2022). Geometry in this study entails exploring fundamental geometric concepts such as 2D shapes and 3D objects, angles, lines, properties of shapes and transformations (Jablonski & Ludwig, 2023; Kuzle & Glasnovic Gracin, 2020;). Two-dimensional (2D) objects refer to objects that has only two dimensions of length and breadth, with no thickness or height. On the other hand, three-dimensional (3D) objects include objects with three dimensions: a length, a breadth, and height. Much of the geometry teaching in most classrooms relies on immersive and adaptive instruction, transitioning from a conceptual to a procedural approach. This approach amalgamates engaging, realistic educational settings with a personalised and data-driven teaching style (Brown, 1999; Chin et al., 2001). Such transitioning impacts the learning of geometry adversely. That is, research indicates that learners exhibit inadequate understanding of geometrical concepts, reasoning and problem-solving skills, contributing to declining performance in Mathematics Paper 2, specifically in geometry (Brown, 1999; Chihambakwe, 2017; Chin et al., 2001). Therefore, this study shows the need for a teaching approach that uses visual aids in a structured way to support Grade 7 learners in understanding geometry and improving their reasoning and problem-solving skills.

This study emphasises that geometry teaching with the use of visual aids at Grade 7 level supports learners in their understanding of the geometry concepts. Visual aids refer to teaching tools that appeal to the sense of sight, tools that include pictures, graphs, infographics, posters, models, demonstrations, simulations and interactive software (Achimugu & Onojahii, 2017). They can help create a more engaging learning environment, improving learner motivation, helping learners conceptualise and better understand mathematical concepts and ultimately improving the learning experience (Vavra et al., 2011). Thus, visual aids are practical tools used by educators in classrooms to enhance learners' comprehension, interest and retention of concepts and information (Al Mamun, 2014).

Learning experience is a methodical strategy for instructing learners that entails reorganising the flow of a curriculum with the purpose of centring attention on its ultimate purposes (Sengeh & Winthrop, 2022). The learning experience places an emphasis on the use of a variety of instructional strategies to captivate all learners. The Grade 7 level of the senior phase is particularly significant in the educational aspect of children in South Africa as it acts as a bridge between primary and high school education. Research has shown that the use of visual aids can have a positive impact on learning (Rowland & Ruthven, 2011). In this regard, the implementation of visual aids has many benefits that include helping learners to identify patterns, reinforcing key concepts and providing a more tactile approach to problem-solving.

Sunzuma and Maharaj (2019) argue that visual aids can help learners make links between different geometric ideas, which can help them understand the subject better. It is important to remember that visual aids only work if they are used the right way. For example, Cox et al. (2009) found that vision tools like magnifiers were only helpful when they were used correctly. Even though visual aids are important in learning geometry, they are not effective if teachers do not have the training and skills to use them properly (Smith & Cekiso, 2020). Recent studies have shown educators in South Africa need to learn more about different visual mathematical aids (Chikiwa & Ludwig, 2023; Smith & Cekiso, 2020;). Therefore, this study highlight that mathematics teachers must be equipped for effective use of visual aids in teaching Grade 7 geometry to impact positively on the learners' learning experience.

1.2 BACKGROUND TO THE STUDY

Multimedia education has attracted a lot of interest recently, including education through use of visual aids. With an emphasis on their use in geometry teaching, this study aligns the practice with benefits and drawbacks of employing visual aids in the classroom. The current study emphasises that visual aids, including charts and graphs, improve learners' academic performance in mathematics. Mathematics educators have the ability to effectively stimulate interest, engage learners in challenging cognitive tasks, facilitate the exchange of mathematical ideas and exemplify mathematical thinking and reasoning (Abramovich et al., 2019). Therefore, multimedia including visual aids can enhance geometry teaching by combining varied representations that stimulate interest, deepen cognitive engagement and strengthen mathematical communication and reasoning, with potential gains in learner performance.

In Australia, learners enjoyed moving from visual to symbolic representation when two-sided were used to generate Fibonacci numbers step by step (Abramovich et al., 2019). However, it should be noted that visual representation conveys mathematical ideas through concrete images or objects; while, symbolic representation expresses these ideas abstractly using numbers, symbols and formal notation (Mainali, 2021). The presence of digital tools greatly aids in the process of transitioning from a visual representation to a symbolic one, which can then be used in mathematical modelling scenarios (Abramovich et al., 2019).

In the United States, the National Council of Teachers of Mathematics and the New York State Education Department stress the need to use multiple forms of representation, such as physical, visual, symbolic, verbal and contextual to deepen learners' mathematical understanding (Ball, 2020). This indicates that mathematical understanding can be strengthened when learners are supported to coordinate and translate concepts across multiple representations, moving from concrete visual forms toward abstract symbolic reasoning, particularly with the support of digital tools.

Such depictions are not only pedagogical tools but also mental bridges to promote internalisation and flexible thinking (Ball, 2020; Maries et al., 2016). Despite this, visual aids are underused in South African Grade 7 mathematics classrooms even though they are recognised as important in assisting understanding of concepts. In other words, several South African teachers recognise the benefits of visual and digital technologies but are hindered from using them due to lack of training, deficient infrastructure and enormous class sizes (Bezuidenhout, 2021). Furthermore, the authors argue that while some interventions include smartboards and visual learning materials, they are used in most cases just to transmit content without full conceptual engagement. The pedagogical intent–classroom practice gap hinders learners from making an effortless transition from concrete to abstract thought in mathematics. In other words, although teachers may intend visual representations to function as bridges for meaning-making and abstraction, classroom constraints often reduce their use to presentation tools, with limited learner interaction and sense-making. This misalignment between intended conceptual mediation and enacted transmission practice constitutes the pedagogical intent–classroom practice gap, thus, weakening the representational work needed for abstraction.

Despite such regional interventions, there is a common issue: learners commonly exhibit representational inconsistency by constructing mathematical and visual models that disconnected. Maries et al. (2016) attribute this to epistemological framing, in which learners use different cognitive strategies or “epistemic games” in moving among representations. Furthermore, without classroom support that shows the value of visual tools, learners may see symbolic methods as more important and ignore simpler, intuitive models such as drawings, physical objects, number lines, and simple diagrams too soon (Ball, 2020). In South Africa, while CAPS recommends the use of visual and tangible supports, it neither offers specific instructional guidance on how to scaffold transitions between modes of representation nor equips teachers with necessary pedagogical expertise. Closing the gap requires more than training and facilities: it also requires curricular integration and models of teaching that include representation as a central aspect of mathematical proficiency.

Visual aids should be a commonplace in modern classrooms to keep learners engaged, to clarify complex ideas and enhance long-term memory. Although visual aids are marked as essential in, their effectiveness and application might vary widely depending on the circumstances (Shabiralyani et al., 2015). Moreover, it is widely believed that using visual aids in the classroom greatly enhances learners’ memory. Learners’ understanding and memory of concepts are improved when visual aids are combined with spoken explanations (Achimugu & Onojahii, 2017). Idris et al. (2018) found that using visual aids, such as pictures, graphs and diagrams, increased understanding and memory because they gave more real-world examples to examine.

Although existing studies provide useful insights on visual aids, there is a lack of research that brings together findings from different contexts to identify common ways to improve their use in education. According to Dimmel and Herbst (2015), a thorough investigation of the effects of visual aids on learning experience across a wide range of educational contexts, specifically in geometry courses, has not yet been done. To address these gaps, this study analyses the impact of visual aids in the classroom using global perspectives and identifies effective practices and areas for improvement.

1.3 PROBLEM STATEMENT

The research problem focuses on ongoing challenges in teaching Grade 7 geometry in South Africa, particularly the limited empirical studies on how visual aids can improve learners' understanding and engagement. This problem is in the larger context of the South African mathematics classroom, where learners still underperform in geometry, an essential mathematics topic on which other studies in engineering, architecture and science are based. Research consistently highlights that there are inherent teaching problems in geometry content area. That is, most teachers lack sufficient subject content knowledge, and this diminishes their capacity to apply pedagogical practices for converting abstract geometric concepts into meaningful, comprehensible learning (Alex & Mammen, 2018; Bansilal & Ubah, 2019). This deficiency often results in teaching being predominantly procedural and rote-based, depriving the learners of an opportunity to develop well-founded conceptual thought (Mabena et al., 2021). Thus, the research problem reflects a dual gap in evidence and practice, namely: i) limited research on visual-aid-based geometry instruction; and ii) persistent classroom conditions that constrain teachers' capacity to support conceptual learning beyond rote procedures.

Furthermore, the learners themselves usually struggle with the very abstractness of the concepts in geometry, which inhibits their knowledge, reasoning and problem-solving abilities (Mosia et al., 2023). These issues are best highlighted through assessment, for example, test assessment such as South Africa's Mathematics Paper 2, where underachievement is an emergent theme through assessment outcome that learners have not internalised basic geometric concepts (Chihambakwe, 2017). This combination of challenges is exacerbated by the minimal inclusion of diverse, multi-representational pedagogies that can bridge abstract theory and concrete learning. Optimal Grade 7 geometry instruction should be characterised using visual materials, including diagrams, models and interactive technologies, as strategic tools that enable learners to view and interact with geometric concepts. This would be a tailored setting where teachers were sufficiently qualified to incorporate these tools in a way which complemented curriculum goals, responded to the different cognitive needs of learners and maximised increased levels of engagement and learning. But that is not the case presently. Instead, the data shows that teachers are not equipped with pedagogical content knowledge and professional support to use such strategies to make an impact (Smith & Cekiso, 2020). Therefore, this highlights that persistent learner difficulty with abstraction, coupled with limited multi-representational teaching and insufficient teacher support, continued to undermine conceptual understanding and performance in geometry.

The inability to master geometry problem-solving, hence, conceptual understanding, not only constrains future development for learners of mathematics but also excludes them from access to STEM-related professions, thus perpetuating cycles of educational disadvantage and socio-economic disadvantage. There are few studies on the exploration of classroom usage of visual aids in Grade 7 geometry, especially in South Africa, which limits the evidence available for educators and policymakers to design effective interventions (Dimmel & Herbst, 2015). The effects of the issue are therefore colossal in proportion, ramifying into individual learner paths, national educational outcomes and general development aspirations. Filling this research gap is essential to establish how visual aids may be used in supporting concept acquisition, enhancing learner engagement and eventually impacting enhanced academic performance in geometry. This study therefore investigated the possibility of visual aids in reshaping Grade 7 learners' learning experience in geometry, generating evidence that could inform the creation of more efficient teaching strategies and educational policies.

1.4 RESEARCH QUESTIONS

The main research question:

How does the use of visual aids in teaching grade 7 geometry enhance the learning experience?

The sub-research questions of this study were as follows:

- What teaching skills are relevant towards using visual aids to enhance Grade 7 learners' geometric learning experience?
- How can the use of visual aids in teaching influence Grade 7 learners' geometric learning experience?
- What geometric learning skills and knowledge are developed using visual aids?

1.5 AIM AND OBJECTIVES OF THE STUDY

1.5.1 Aim

This study aim was to explore the use of visual aids in teaching Grade 7 geometry to enhance the learning experience.

1.5.2 Objectives

The research objectives of this study are:

- To explore the teaching skills relevant towards using visual aids to enhance Grade 7 learners' learning experiences in geometry.
- To determine how the use of visual aids in teaching influence Grade 7 learners' geometric learning experience.
- To identify the geometric learning skills and knowledge that are developed using visual aids.

1.6 RATIONALE OF THE STUDY

Investigation of the influence of visual aids on learning Grade 7 geometry is no trivial concern. Grade 7 geometry is a gateway to various fields of study, including computing, engineering and architecture, where spatial reasoning and geometric manipulation are all-important (Depardieu, 2019; Grigaliūnienė et al., 2025; Mukuka & Alex, 2024). However, despite playing a central role, a wide range of evidence explains that many learners struggle with the abstractness of geometric concepts and thus hinder their comprehension and problem-solving ability (Bansilal & Ubah, 2019; Brown, 1999; Chin et al., 2001; Mabena et al., 2021). These difficulties are normally compounded by pedagogy that fails in scaffolding the learners' transition from the concrete to the abstract. This underscores the importance of examining pedagogical interventions, such as the use of visual aids, in making abstract geometric ideas more comprehensible and in helping learners learn the essential knowledge required for advanced studies and professional ends.

This study determined the most efficient visual aids for teaching Grade 7 geometry. The findings of this study guides educators and instructional designers on choosing suitable visuals to improve learners' comprehension and academic success. The current study highlights the difficulties and restrictions that arise when incorporating visual aids in teaching Grade 7 geometry. Educators should use this information to overcome obstacles and optimise the advantages of incorporating visual aids into their lessons. For the purposes of this study, the terms educators and teachers are used interchangeably to refer to qualified professionals responsible for facilitating teaching and learning in the classroom. Furthermore, this study commends the use of visual aids in teaching mathematics, in particular Grade 7 geometry. The findings of this study advance a useful knowledge base for further research in mathematics education field. This is essential in improving the quality of mathematics education and improvement in learners' academic performance.

In addition, the current study has practical implications for stakeholders in education. Policymakers can use this study's findings to develop policies that support the use of visual aids in teaching Grade 7 geometry; the findings support curriculum development towards curricula that incorporate effective use of visual aids in teaching geometry. The educators can apply the results to enhance their teaching through the best type of visual aids and attend training sessions to enhance their skills in the use of visual aids. In addition, this study's findings support meaningful learning of geometry through improved learning outcomes, thereby improving academic performance in mathematics and building confidence in learning, critical thinking and applying mathematical concepts.

1.7 KEY TERMS

The definitions below apply to the key terms used in this study.

1.7.1 Visual aids

In the context of this study, visual aids are understood not merely as non-textual supplements but as a comprehensive array of pedagogical instruments deliberately crafted to translate abstract geometric concepts into concrete, interpretable forms. They encompass diagrams, graphs, pictures, models and interactive digital representations that serve as cognitive bridges, facilitating the internalisation of spatial properties and relationships which are otherwise difficult to grasp through purely verbal or symbolic explanations. Aligned with Duval's theory of semiotic representation, visual aids function as vehicles through which learners can engage with iconic systems to build multi-dimensional understandings essential for geometric reasoning (Shabiralyani et al., 2015). As such, visual aids were positioned as semiotic and cognitive resources that enabled learners to interpret geometric relationships and coordinate visual insight with formal mathematical meaning.

1.7.2 Learning Experience

The notion of the learning experience in this study extends well beyond the linear delivery of curriculum content. It refers to the holistic orchestration of pedagogical encounters through which learners actively navigate, interpret and internalise mathematical ideas. According to McLeod (2024), this involves restructuring curricular flow to focus on ultimate goals. Here, it specifically includes how visual aids reshape cognitive and affective engagement with geometry by fostering richer conceptual exploration, heightened motivation and sustained intellectual curiosity, culminating in deeper and more meaningful understanding.

1.7.3 Geometry

Geometry in this research is not confined to being a mere branch of mathematics concerned with sizes, shapes and spatial properties, as traditionally defined by Depardieu (2019). Instead, it is envisioned as a reasoning discipline which invites learners to move from physical experiences of shapes and objects to representations of manipulations in relation, form and space. Furthermore, Grade 7 geometry involves formally exploring two and three-dimensional figures, lines, angles and transformations, all requiring learners to balance perception with formal deductive argument, a reason why the use of visual aids is of critical importance.

1.7.4 Constructivism

Constructivism serves as a philosophical foundation for this study by positioning learners as active agents who build knowledge through their interactions with the environment (McLeod, 2024). In this context, visual aids are not passive illustrations but essential tools that enable learners to manipulate representations, discern patterns and generate their own meanings. This active cognitive engagement is pivotal in supporting learners as they advance from recognising simple geometric figures to engaging in higher-order deductive reasoning about complex geometric relationships.

1.7.5 Scaffolding

The concept of scaffolding in this study transcends its original educational intention of temporary support. It denotes carefully calibrated instructional interventions that help bridge the gap between learners' existing knowledge and their potential understanding. Scaffolding here is closely tied to the strategic deployment of visual aids, which educators use to incrementally elevate learners' grasp of geometric concepts by providing structured representational support that stimulates independent reasoning (Kruger, 2021). In this regard, scaffolding is conceptualised as the deliberate sequencing of visual supports that progressively shift learners from guided interpretation toward independent geometric reasoning.

1.7.6 Educator Training

Educator training is framed in this study as a focused process meant to equip teachers with the specific content knowledge, pedagogical strategies and representational expertise required to effectively integrate visual aids into geometry instruction (Smith & Cekiso, 2020). It means helping teachers choose, plan and use visual representations in ways that match curriculum goals and support different learner needs, creating an active and engaging geometry classroom.

1.7.7 Professional development

Professional development is here conceived as an ongoing, recursive process through which teachers continually adjust their instructional strategies, specifically in the use of visual aids to teach geometry (Kennedy, 2016). It consists of structured activities like workshops, peer work and reflective practice that cumulatively build teachers' pedagogic content knowledge and broaden their instructional repertoire for assisting learners via multiple representations and thereby increase classroom efficacy.

1.7.8 Teaching with visual aids

Teaching with visual aids in this study represents more than sporadic use of visual materials. It signifies a deliberate pedagogical orientation towards employing visual representations to deepen learners' approaches to learning, elevate engagement and improve outcomes in geometry (Coetzer et al., 2023; Schoenherr & Schukajlow, 2024). This practice involves the systematic integration of visual modes of communication to clarify abstract geometric concepts, making them more accessible, meaningful, and memorable to learners. Visual representations, manipulatives, and dynamic geometry environments have been shown to support learners' spatial reasoning, conceptual understanding, and the transition from concrete experiences to abstract geometric thinking (Ponte et al., 2023; Boonstra et al., 2023).

1.8 RESEARCH DESIGN

This study was situated within an interpretivist paradigm, which values the socially constructed character of knowledge and the salience of making sense of participants lived experiences in their learning environments. Consistent with this philosophical orientation, this study employed a qualitative methodology and applied the phenomenological approach to explore how the use of visual aids impacts Grade 7 learners' learning experiences in geometry. A purposive sampling approach was used to select Grade 7 mathematics teachers who teach geometry and have experience with visual aids in their instruction. These teachers had received training in the use of visual aids for mathematics teaching through workshops conducted by the Department of Basic Education over a period of five to ten days per year. Learners who had recently been introduced to geometry using these visual aids were also purposively selected to participate in this study. Data collection involved semi-structured interviews with teachers, permitting latitude in asking about their teaching decisions, issues and conceptualisation of how the use of visual aids had impacted learners' involvement and understanding. Non-participatory observation of classrooms was also employed to gain naturalistic perspectives on learners' involvement with visual aids during lessons on geometry, giving a representative picture of what happened in the classroom. Data were examined using thematic analysis, which facilitated systematic coding and categorisation of data to identify repeating patterns and themes. The method allowed a deep insight into the effects of visual aids on learners' comprehension, motivation and participation, ultimately yielding results that became relevant to this study's rationale of informing improved pedagogy in geometry.

1.9 CHAPTER OUTLINE

This study was organised into five chapters which are described below:

Chapter 1 discusses the introduction and background of this study which gave the context of this study. The chapter also outlined the research problem, research objectives and the rationale of this study.

Chapter 2 discusses the literature of this study associated with the use of visual aids on the improvement of learning experience in Grade 7 geometry. This literature looks at the importance of visual aids in teaching geometry as well as the associated challenges and limitations of using visual aids.

Chapter 3 discusses the research design of this study which encompass the research paradigm, research methodology, research approach/method, population and sample, data collection instruments and process, data analysis and ethical considerations.

Chapter 4 discusses the data analysis and findings of this study which is composed of the themes generated from collected data.

Chapter 5 discusses the conclusions and recommendations of this study in relation to the objectives of this study. Furthermore, areas of future research are suggested.

1.10 CHAPTER SUMMARY

This study addressed the global challenge of poor mathematics performance which focused on South Africa's unique struggles despite extensive reforms. It was reported that geometry, a critical yet abstract area, was particularly challenging due to gaps in educators' knowledge and effective teaching strategies. Visual aids such as diagrams and models have the potential to enhance Grade 7 learners' comprehension, engagement and retention of geometric concepts, bridging the gap between abstract ideas and practical understanding. However, their effectiveness depended on proper training and application by educators. This research explored the use of visual aids in teaching grade 7 geometry to enhance the learning experience, to inform strategies that supported educators, curriculum developers and policymakers in enhancing mathematics education. The next chapter presents the literature review of this study.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 INTRODUCTION

There is an increasing need for visual aids to be used in Grade 7 geometry lessons. In the subject of mathematics teaching, using visual aids like diagrams, models, simulations and interactive software has shown to be effective. Research shows the importance of visual aids in helping learners understand geometric ideas that are becoming more and more complicated (Shabiralyani et al., 2015; Idris et al., 2018). The gap between abstract mathematical ideas and their real-world applications can be crossed with the use of visual aids. Using visual aids, can improve learners' focus, motivation and excitement (Chundung et al., 2020). Their usefulness for teaching geometry has been called into doubt. Nevertheless, it has been shown that there are both beneficial and detrimental impacts on learners' performance (Ashikuzzaman, 2024; Noon, 2024). This discrepancy calls for investigation into the most efficient ways to include visual aids into geometry instruction. Therefore, this Chapter presents literature reviewed to highlights the use of visual aids to teach the seventh-Grade geometry for the enhancement of the learners' geometric learning experience. from diverse contexts. This chapter also present the theoretical framework to provide a theoretical lens towards the study; and ultimately the synthesis is presented to contextualise the integrated context of both the reviewed literature and the theoretical perspective.

2.2 LITERATURE IMPLICATIONS

Literature was reviewed from journal articles, scholarly books and conference proceedings to discuss the following themes, visual aids for teaching geometry; how visual aids can support the learners' learning experience; effectiveness of visual aids on the development of the learners' geometric learning experience; the use of visual aids in geometry towards development of learners' learning experience; and challenges of using visual aids in teaching geometry.

2.2.1 Visual aids for teaching geometry

In the context of teaching Grade 7 geometry, visual aids have emerged as essential pedagogical tools that substantially shape learners' cognitive, metacognitive and affective experiences. Current research provides strong information on what type of visual aids are, what they encompass, how they are used and how they influence learners' engagement, conceptual knowledge and problem-solving skills. Manipulatives made up of tangible physical objects such as geometric solids, pattern blocks and tangrams comprise one of the most critical visual aids categories. Manipulatives allow learners to literally manipulate and explore geometric shapes, thus embedding abstract concepts into concrete experiences. Research by Ponte et al. (2023) demonstrates that manipulatives serve both recreational and cognitive roles, enabling learners to classify, construct and distinguish shapes such as triangles, squares and circles and to progress from the Van Hiele visualisation phase to more advanced analytical reasoning about geometric properties (Baiduri et al., 2020). This positions manipulatives as a central visual-aid modality through which learners' engagement with shapes could move from hands-on visualisation to more analytic reasoning about geometric properties.

Static graphical representations, including textbook diagrams, board sketches and educational posters, are also widely used in geometry classrooms to depict spatial relationships and figure properties. Žakelj and Klancar (2022) argue that static images are essential for linking learners' visual perceptions to more abstract formal reasoning, especially when instruction progresses systematically from concrete to pictorial and then to symbolic representations. However, their study also highlights that learners often struggle to independently generate or analyse such static diagrams, underscoring the importance of explicit scaffolding to help them interpret and use graphical representations effectively (Žakelj & Klancar, 2022). Dynamic visual aids, which encompass animations, interactive simulations and dynamic geometry software such as GeoGebra and Cabri3D, represent another critical category (Adelabu et al., 2019b; Jaya & Suparman, 2021; Juandi et al., 2021). These tools enable learners to manipulate geometric figures in real time, observe invariant properties under transformations and visually test conjectures, thereby cultivating an exploratory and investigative approach to learning. Serin (2020) found that technology-aided geometry instruction enhances learners' motivation and engagement, helping them to overcome difficulties in understanding abstract geometric concepts by providing immediate visual feedback. Likewise, Juandi and Juandi (2020) show that dynamic environments actively support processes of construction, manipulation and logical deduction, all of which are essential for deeper geometric thinking.

Multimedia visual aids, including virtual manipulatives and interactive digital platforms, extend these benefits by blending text, visuals and user-driven exploration to create multisensory learning environments. Virtual manipulatives function as digital equivalents of physical models, allowing learners to experiment with and visualise geometric concepts in ways that support transitions from concrete manipulation to abstract reasoning (Moyer-Packenham and Bolyard, 2016). These types of tools have proven to encourage learners to think critically and manage their own thinking processes, thereby cultivating worthwhile metacognitive abilities as well as spatial sense. In addition, infographics and data visualisation tools embedded in tools, though more common in higher-level math and inter-disciplinarily context, are becoming increasingly regarded as contributing to the cultivation of visual mathematical literacy even at the primary level. Virtual manipulatives help learners see how geometric ideas relate to the real world. This makes abstract concepts easier to understand and prepares learners to use complex visual representations for advanced problem-solving (Deringöl, 2020). This indicates that digital visual tools could broaden geometry learning by enabling exploratory interaction with representations that strengthened spatial reasoning, metacognitive regulation, visual mathematical literacy and the translation of abstract properties into interpretable, real-world connections.

As such, literature proves that the intentional use of diverse visual instruments greatly transforms learners' experiences of geometry. They aid in the construction of spatial visualisation, broaden conceptual knowledge, increase learner motivation and engagement and facilitate critical cognitive and metacognitive processes. In offering several representational paths, that is, concrete, pictorial, dynamic and symbolic experience, visual aids enable learners to develop robust internal representations of geometric concepts. Such multimodal strategy is especially critical in geometry was moving from recognising shapes by their appearance to rationally inferring their properties is contingent upon well-ordered visual experiences supplemented with targeted instructional interventions. Therefore, integrating a variety of visual aids into teaching Grade 7 geometry is not only an instructional enrichment but is an intrinsic pedagogical approach necessary for shaping learners' overall learning experience.

2.2.2 Learners' geometric learning experience

On the analysis of the impact of instruction of geometry using visual aids on Grade 7 learners' learning experience, it is important to recognise that learning experience in this study transcends exposure to curriculum content. Therefore, it is an integrated dynamic process whereby the learner actively engages with, constructs meaning and comprehends geometric notions through highly structured pedagogical encounters centred upon visual representations. This integration directly contributes to this by presenting learners with various semiotic paths to understandings, thus improving not just comprehension but also deeper cognitive engagement.

Teaching approaches can be applied in an effort to engage visual representations and guided discovery with scaffolding (Gebremeskel et al., 2025). For example, using structured models of guided discovery, lead to considerably enhanced conceptual knowledge, engagement and problem-solving ability (Gebremeskel et al., 2025). In addition, the research findings indicate that visual supports in geometry teaching are not additive but are a key component of the construction of learning experiences leading to long-term and transferable comprehension. Therefore, learning experiences are acquired through pedagogies that allows learners to manipulate, study and synthesise geometric concepts visually and contextually. As learners engage with diagrams, dynamic software or three-dimensional models, they move beyond memorisation towards actively constructing meaning. This dynamic visual experience promotes changes from low-level shape perception to higher-order deductive reasoning, which fits perfectly with how successful learning geometry actually happens in the mind (Gebremeskel et al., 2025). This indicates that scaffolded guided-discovery pedagogy operationalised visual representations as core learning mechanisms that shifted learners from perceptual recognition and memorisation toward conceptual construction, problem-solving and deductive geometric reasoning.

The cognitive and conceptual implications are profound. Experiential learning paradigms study points out that when the learners participate actively in building knowledge by connecting new geometric patterns to current mental patterns through visual activities, they demonstrate increased retention, flexibility of reasoning and superior creative potential. This is significant to tackle complicated spatial issues both inside and outside the classroom (Kohn Rådberg et al., 2020; Uyen et al., 2022). Moreover, Darling-Hammond et al. (2024) emphasise that deep learning experiences, which integrate social, emotional and cognitive factors, form the core of developing executive functioning, metacognitive regulation and a growth mindset. Visual aids in Grade 7 geometry class serve this purpose of anchoring abstract concepts to the more tangible and observable, reducing cognitive load and establishing an environment where learners feel intellectually stimulated and emotionally supported.

The use of visual aids also enhances learners' sense of relevance and personal importance of geometry. Technology such as interactive visualisation environments or culturally relevant diagrams makes learning connect with learners' day-to-day experience and thereby increase motivation, extended curiosity and willingness to tackle hard geometric problems (Alabi, 2024; Hlongwana et al., 2025). This rich engagement not only lies at the heart of the mastery of geometric material in the immediate sense but also sets the foundation for learners' long-term cognitive development and preparedness to handle progressively more challenging mathematical concepts. Therefore, in the present context of this study, the process of instruction through the usage of visual aids in Grade 7 geometry becomes an essential pedagogical pathway in developing learners' spatial thinking, conceptual knowledge and inherent motivation. It lends support to the argument that carefully designed visual pedagogies transform the typical learning of geometry into cognitively rich, individually meaningful and conceptually informed learning experiences.

2.2.3 How visual aids can support the learners' learning experience

There is increasing recognition that enhancing test scores alone is insufficient to address the challenges associated with geometry instruction; rather, emphasis must be placed on enriching the learners' daily classroom experience. In the South African context and similar education systems, the persistence of traditional, teacher-centred pedagogies continues to constrain meaningful engagement with geometry. These methods often prioritise rote memorisation over conceptual understanding and spatial reasoning, resulting in passive learning environments that hinder the learner's ability to internalise geometric principles (Mabena et al., 2021; Sinyosi, 2015). In response to this, literature has increasingly focused on how the use of visual aids can actively transform the learning environment and influence learners' experience in the mathematics classroom. The use of visual media such as diagrams, dynamic geometry software, models and charts has been shown to effectively bridge the gap between abstract mathematical content and concrete learner understanding (Schoenherr et al., 2024). Kristiawan and Kumalasari (2023) illustrate that visual learning media make mathematical instruction more engaging, provoking learners' curiosity and facilitating active learning. This change in engagement provokes learners to question, discuss with others and gain deeper conceptual understanding. Dlamini and Nkambule (2020) demonstrated that visual representations open the space for meaning making in the classroom. Learners use such representations to represent, argue and make sense of their ideas and increasingly become confident and make geometry an interactive instead of a passive subject to experience.

Spatial and critical thinking abilities are particularly well developed by using visual aids. Glynn (2022) points out that schematic diagrams and manipulatives initiate learners' ability for visualising, rotating and inter-relating geometric shapes mentally. These are abilities that are crucial for solving geometric problems. Visual aids, in contrast to verbal or written descriptions, allow learners to conceive and manipulate mathematical objects mentally, making geometry less overwhelming and easier to handle. This promotes a shift in perception from mathematics as formulaic and closed to a discovery discipline founded on visible and manipulable structures. Secondly, Oji (2024) emphasises the importance of differentiation through the use of visual aids in multilingual classrooms. Learners with varying linguistic backgrounds or varied cognitive styles highly value learning materials that are multisensory. They offer different routes to knowledge, especially where language or conventional instruction carries a barrier. In this regard, they are most applicable in multilingual and resource-scarce learning environments like South Africa's, where few learning support materials have the biggest impact on learners from poor backgrounds (Reddy et al., 2016). Accordingly, this indicates that visual aids could simultaneously strengthen geometric problem-solving through spatial–critical thinking and widen access to meaning-making through differentiated, multisensory pathways in multilingual and resource-constrained classrooms.

Nevertheless, the success of visual aids depends on the teachers' capacity to use them tactically. Sternberg (2023) opines that professional growth toward visual pedagogical competency is essential in ensuring that the use of visual aids enhances, as opposed to detracting from, the learning process. This is corroborated by Noon (2024), who emphasises teacher adaptability and creativity, particularly in inadequately resourced environments where improvisation of learning materials is the norm. Importantly, teachers who are provided with targeted training are more inclined to develop learner-centred lessons that make geometric ideas visible, tangible and doable. Chapman (2015) contends that rich pedagogical content knowledge allows teachers to connect learners' everyday experiences with abstract mathematical content, thereby making learning more applicable. The teacher's expertise does not only rely on familiarity with mathematical facts but on conveying them in ways that relate to the daily lives of learners and stimulate questioning. Contrarily, Heggart (2016) challenges the traditional disproportionate emphasis on subject matter proficiency, stating that the correlation between teacher content knowledge and learner performance is smaller than anticipated. Instead, he emphasises classroom interaction, feedback and engagement strategies, all of which visual aids can greatly facilitate if used with a purpose.

In spite of this, there are many systemic and structural problems that remain. Michael (2017) observes that one of the main obstacles to good mathematics teaching in much of the developing world continues to be the lack of teaching resources, such as textbooks and physical teaching aids. Here, there is a reliance on teacher talk and chalkboard exposition, diminishing the learner's possibilities for interaction with and visualisation of geometrical content. This reproduces inequalities and discourages possibilities for learners to experience mathematics as exploratory and participative. In addition, while global concern over underachievement in mathematics is typically expressed in terms of low achievement scores (Sinyosi, 2015). There is a growing body of literature that demands attention to be given to the learning experiences as perceived by the learner. Poor performance, especially in geometry, is often the result of aversive classroom experiences caused by boredom, alienation and non-representation in teaching materials. As Reddy et al. (2016) illustrate, findings from international benchmarking studies refer not only to low achievement levels in South Africa but also indicate gaps in learner engagement and motivation. These are dimensions that are more directly linked to classroom experience rather than content coverage.

Considering the discussion above, recent studies validated that the learning experiences of geometry classes are primarily influenced by the presentation of content. Visual aids offer a potential for redesigning these experiences in a way that mathematics becomes more interactive, inclusive and cognitively challenging. Teachers themselves find themselves in the middle of the change and must be facilitated by ongoing professional development that focuses on technical competence and relationship pedagogy. The investigation of visual aids is thus not a pedagogical option but an imperative reply to historical inequities and contemporary learning challenges. This is in accordance with the overall endeavour of improving education equity and performance in activities that raise learners' engagement, comprehension and confidence in geometry.

2.2.4 Effectiveness of visual aids

A growing body of literature underscores the significant impact of instructional strategies employing visual aids on learners' mathematical learning experiences, supporting both conceptual understanding and the development of adaptive cognitive processes. Early work by Naqvi et al. (2014) found that combining traditional tools such as chalkboards with modern approaches like animations yielded superior outcomes, improving engagement and comprehension across instructional settings.

Similarly, Anggo and Arapu (2018) highlighted that while certain tools such as overhead projectors were sometimes perceived by learners as distractions, well-integrated visual aids support metacognitive skills by enabling learners to plan, monitor and evaluate their mathematical problem-solving approaches. More recent research by Yorulmaz et al. (2023) confirmed this relationship, showing that structured visual supports heightened learners' number sense while also strengthening their metacognitive capacity to regulate and reflect on their learning processes. Studies by Ambarini et al. (2018) and Pujiastuti and Mashuri (2017) further revealed that teaching aids adapted to learners' cultural contexts improved the development of fundamental mathematical concepts. These tools allowed learners to see, feel and directly think about the mathematical objects under study, supporting both sensory engagement and abstract reasoning (Ambarini et al., 2018; Pujiastuti & Mashuri, 2017). These insights are reaffirmed by more recent work from Ellis (2019), who argued that culturally responsive visual representations deepen learners' comprehension, foster identity in mathematical learning and enhance their ownership of the subject. Moreover, this indicates that the effectiveness of visual aids depended on purposeful integration and cultural responsiveness, as these conditions simultaneously strengthened learners' metacognitive regulation, conceptual development and sense of ownership in mathematical learning.

The importance of well-designed instructional materials has also long been recognised. Earlier concerns by Van Rooyen and Van der Merwe (1996) indicated that poorly crafted visual aids could lead to misconceptions and misinterpretations, highlighting the need for instructional precision. This foundational caution is robustly supported by Schoenherr and Schukajlow (2024), whose comprehensive scoping review concluded that high-quality external visualisations reduce confusion and strengthen learners' conceptual clarity, demonstrating that thoughtful visual design is essential for effective mathematics teaching. Targeted studies on geometry further illustrate how diverse visual aids transform learners' experiences. Ladin and Mazan (2021) showed that the use of Display Light Board (DLB) media improved learners' ability to recognise and reproduce geometric shapes, directly enhancing their spatial visualisation skills. Similarly, Žakelj and Klancar (2022) noted that systematic use of graphical representations and technological environments helps learners progress from concrete manipulation to pictorial reasoning and abstract thought, which is a foundation for building solid geometric knowledge. This indicates that instructional precision in visual design, coupled with systematic use of diverse visual representations, reduced misconceptions and enabled learners to build spatial skills and progress toward abstract geometric reasoning.

Cumulatively, these results from both classic and contemporary research confirm that carefully integrated visual aids, whether through combined traditional and animated methodologies, culturally responsive graphics, dynamic geometry software or carefully designed manipulatives, strengthen learners' mathematical and geometric learning experiences. They accomplish this through building conceptual understanding, sustaining engagement and building essential metacognitive and adaptive reasoning skills. This links to the aim of the study, which is to examine how visual aids in teaching geometry affect the learning process of Grade 7 learners by shaping how they understand and engage with geometric concepts.

2.2.5 Development of the learners' geometric learning experience

Visual aids assist learners in visualising the shapes, angles and dimensions crucial to geometry, facilitating a more accessible comprehension and application of the concepts (Baydas & Yilmaz, 2018). Visual aids like diagrams, models and animations are used in the teaching of geometry to demonstrate the relationships between geometric shapes and dimensions. For instance, using a 3D shape model can aid learners in conceptualising the shape's measurements and characteristics (Dlamini & Nkambule, 2020). Furthermore, visual aids have the potential to improve learners' spatial reasoning abilities, which play a key role in learning geometry (Varthana, 2024). Spatial thinking is the skill of mentally picturing and controlling objects in space. Additional visual aids, such as virtual manipulatives and interactive software, enable learners to engage with geometric shapes, aiding in the development of spatial reasoning skills (Moyer-Packenham et al., 2019). This indicates that a range of visual tools, from concrete models to interactive digital resources, support geometry learning by making relationships among shapes and dimensions perceptible and by strengthening the spatial reasoning required to interpret and manipulate geometric objects.

Moreover, the effective use of visual aids in teaching geometry involves several best practices. First, educators should carefully select visual aids appropriate for the concepts taught (Zulkifli et al., 2022). The model can be used, for instance, to depict shapes of geometrical figures while a diagram can be used to display the relationship of various shapes with respect to their dimensions. Lastly, educators need to ensure visual aids are used appropriately in the lesson aligned with the lesson plan. Visual aids should not be a distraction but a tool to facilitate learning (Dlamini & Nkambule, 2020). Thirdly, educators must guide learners on how to use visual aids effectively through teaching them how to read and interpret diagrams, models and other visual aids (Baydas & Yilmaz, 2018). Finally, educators must use visual aids to encourage active learning. For example, learners can be asked to draw shapes, calculate angles and measure distances using visual aids (Dlamini & Nkambule, 2020). This indicates that effective geometry instruction depends not on the mere presence of visual aids, but on their careful selection, coherent integration, explicit interpretive guidance and active learner use.

Furthermore, diagrams, pictures, graphs, videos and models can help learners to understand geometry better and to remember complex ideas (Abdulrahaman et al., 2020; Varthana, 2024). Adelabu et al. (2019a) state that when visual aids are used to teach geometry, learners can better remember mathematical ideas and use them to solve problems. Also, a study by Kristiawan and Kumalasari (2023) shows that visual aids can boost learners' interest and their desire to learn mathematics, which helps them do better in school. It is only possible to teach geometry with visual aids such as diagrams, models and animations to help learners build spatial thinking skills by giving them a way to understand ideas. For example, using a model to show geometric shapes and sizes can help learners better understand the ideas and this visual representation can help learners get better at handling spatial relationships and solving geometric problems (Thompson & Chappell, 2007). In addition, by putting together visual aids and real-world examples, learners can better understand and use what they learn in mathematics.

Furthermore, visual aids contribute to the development of visualisation skills, which are fundamental in geometry (Gunčaga et al., 2020; Žakelj & Klancar, 2022). Through regular exposure to visual representations, learners can strengthen their ability to mentally manipulate shapes, comprehend transformations and spatial relationships. Many studies have looked into how well visual aids work in teaching mathematics. Guven and Gulbahar (2020) found that graphic tools can help learners understand geometric ideas and improve their problem-solving ability. Diagrams and other visual aids can help learners find trends, remember essential ideas and solve problems in a more hands-on way. Rowland and Ruthven (2011) state that using visual aids in mathematics can make learning more involved and exciting, motivating learners and improving their grades. Moreover, visual aids facilitate problem-solving by offering learners a platform to explore geometric problems visually (Žakelj & Klancar, 2022). Moreover, through manipulating shapes, observing patterns and experimenting with different strategies, learners can develop critical thinking skills and arrive at deeper understandings.

Visual aids can help learners see and understand the forms and sizes when teaching geometry. For example, models can be used to show geometric figures' shapes and sizes, making it easier for learners to see how these ideas are related. Furthermore, Mainali (2021) argues that using visual aids to teach mathematics can help learners in several ways. For example, visual aids can help make abstract ideas more real by giving learners a picture of the idea, making it easier for them to understand and remember. Visual aids can also interest learners in the lesson and encourage them to participate and ask questions.

Furthermore, visual aids provide clarity and precision in communicating geometric information (Smith & Cekiso, 2020). They offer a clear and concise means of illustrating key concepts, reducing the potential for misunderstandings that may arise from verbal or written explanations. Furthermore, visual aids cater to diverse learning styles and transcend language barriers (Oliveira, 2024; Varthana, 2024). Regardless of language proficiency or learning preferences, learners can interpret geometric concepts through visual representations, making geometry more accessible and inclusive. It has been found that there are many benefits to teaching mathematics with visual aids. Visual aids make the classroom more dynamic and exciting, getting more learners involved and helping educators teach better (Adelabu et al., 2019a). Visual aids are also a more exciting way to explain mathematical topics, making learners more interested and motivated to learn. Kristiawan and Kumalasari (2023) have shown that learners who are driven and interested in mathematics tend to do better than those who are not. In addition, visual aids help bridge the gap between abstract geometric concepts and real-world applications (Shabiralyani et al., 2015). Furthermore, by illustrating how geometry is used in architecture, engineering, art and other fields, visual aids help learners appreciate the relevance and practicality of geometry in everyday life.

Even though there are many good reasons to use visual aids when teaching geometry, there are also some possible wrong reasons (Schoenherr & Schukajlow, 2024). The current highlights that certain visual aids might require modification to enhance learners' comprehension on geometric concepts. Furthermore, inadequate use of visual aids can divert focus from the primary lesson objective (Schoenherr & Schukajlow, 2024). Furthermore, if the visual aids are not properly incorporated into the lesson plan, they may hinder effective teaching towards supporting learners to understand and apply the concepts being taught (Schoenherr et al., 2024). However, some things cannot be done with visual aids in mathematics teaching. Amin et al. (2021) say that using visual aids incorrectly or too much can confuse learners and make it harder for them to focus on the essential mathematical ideas being taught. Also, visual aids can be too complicated, which can confuse learners and defeat the point of the aids (Skulmowski, 2022). In agreement, Zodik and Zaslavsky (2007) assert that the choice and use of visual aids examples present challenges for educators, as specific examples can either facilitate or impede learners' learning. Also, it should be noted that learners may sometimes struggle with visual aids due to their tendency towards prototypical thinking and difficulties in perceiving diagrams in different ways.

The literature discussed above underscores the critical role of visual aids in enhancing the comprehension and application of geometric concepts among Grade 7 learners. Research emphasises that visual aids, such as diagrams, models and animations, facilitate the visualisation of geometric shapes, angles and dimensions, making abstract concepts more tangible and accessible (Dlamini & Nkambule, 2020). Moyer-Packenham et al. (2019) argue that interactive tools and virtual manipulatives bolster spatial thinking, which is essential for geometry. Moreover, the effective selection and integration of visual aids into lesson plans, as discussed by Zulkifli et al. (2022), ensure that these tools enhance rather than distract from learning. Abdulrahaman et al. (2020) and Adelabu et al. (2019a) illustrate that visual aids support in the retention and application of geometric knowledge, boosting learner interest and performance. Studies by Kristiawan and Kumalasari (2023) and Schoenherr et al. (2024) further validate that visual aids can motivate learners and improve their academic outcomes by making learning more engaging and relatable. However, caution is given against the potential pitfalls of visual aids, such as oversimplification or distraction, as noted by Amin et al. (2021) and Zodik and Zaslavsky (2007). As such, the literature substantiates the positive impact of visual aids on learning geometry.

2.2.6 Challenges of using visual aids in teaching geometry

Teaching geometry traditionally involves using visual aids such as diagrams, models and animations to help learners grasp its abstract concepts. Despite the benefits they offer in enhancing learners' learning, visual aids also present several challenges and limitations. A major difficulty when using visual aids in teaching geometry is the risk of visual aids becoming overly complicated, causing confusion among learners (Schoenherr & Schukajlow, 2024). Visual aids need to be thoughtfully created to fit the concepts being taught and not be too advanced for the learners' comprehension level. Moreover, if visual aids are not used effectively, they may serve as a hindrance by detracting from the main material of the lesson (Bui, 2024). Considering this, using visual aids can present difficulties when teaching geometry to Grade 7 learners because of their cognitive development, lack of prior knowledge and short attention spans. Elaborate visual aids can be too much for learners, causing cognitive overload and confusion, especially when paired with new language and vocabulary (Oji, 2024). In addition, it is crucial for educators to choose and create visual aids for Grade 7 learners with different learning styles and abilities, ensuring they are clear, concise and adequately structured to help learners grasp the information. In order to help learners improve their ability to interpret geometric representations, educators need to offer guided practice and feedback on how to effectively use visual aids (Oji, 2024). This indicates that visual aids enhanced geometry learning only when they were developmentally appropriate, clearly designed and pedagogically scaffolded, because poorly selected or overly complex visuals could distract learners and increase cognitive overload.

Another difficulty in incorporating visual aids when teaching geometry is the risk of depending too much on visual aids. Excessive use of visual aids may hinder learners from comprehending and implementing the lesson concepts effectively (Yaffe, 2019). Visual aids should help learners learn instead of being the focal point of the lesson. In Grade 7 geometry classes, excessive use of visual aids could hinder learner development due to various factors. Firstly, over-reliance on visual aids may promote passive learning whereby learners depend on the aids instead of engaging with and internalising geometric concepts (Ashikuzzaman, 2024). In addition, the complex visual may lead to learners' cognitive overload and impede their processing and understanding of the material. According to Shabiralyani et al. (2015), overemphasis on visual aids may also lead to the neglect in the development of other important skills, such as abstract reasoning and critical thinking, which are necessary for mastering geometry. To reduce these challenges, teachers should balance visual aids with other teaching methods. This approach supports active learner participation without relying only on visual aids (Noon, 2024). This indicates that visual aids were most effective in Grade 7 geometry when used as balanced supports for active learning, since over-reliance could encourage passivity, increase cognitive overload and weaken the development of abstract and critical reasoning.

Furthermore, the constraints of the resources available to a classroom may limit the application of visual aids in the teaching of geometry. Lack of access to visual aids like 3D models in low-resourced settings, that is, in schools characterised by limited financial resources, inadequate infrastructure, insufficient teaching and learning materials, and restricted access to educational technologies compromises instruction quality, according to Dlamini and Nkambule (2020). Thus, it hinders educators from confidently incorporating visual aids into their lessons and potentially limits learners' ability to develop a comprehensive understanding of geometric shapes. To address these limitations, educators may need to improvise, seek alternative resources or prioritise the use of visual aids that are readily accessible (Ashikuzzaman, 2024; Noon, 2024; Zodik & Zaslavsky, 2007). Furthermore, professional development opportunities and collaborative efforts within the educational community can help educators overcome resource constraints and enhance the effectiveness of visual aids in Grade 7 geometry instruction (Cansoy & Turkoglu, 2022; Jadallah et al., 2023; Mizell, 2010). Educators must be creative and use alternative visual aids such as diagrams or simple sketches to overcome the lack of resources. Individual differences in learning style can affect the effectiveness of using visual aids (Boyer, 2004). This suggests that resource constraints and learner variability shaped the feasibility and impact of visual aids in Grade 7 geometry, thereby elevating the importance of teacher improvisation, accessible representations and professional support to sustain conceptual learning.

Sometimes, some learners do not learn from visual aids well and may need other different instruction methods (Lowrie & Logan, 2023). Learners have different learning preferences that are visual, auditory, kinaesthetic and tactile learning styles. While visual aids can help learners of a visual kind with more concrete representations of geometric concepts, pure visual information may not engage the auditory learner. According to St Louis (2017) and Glynn (2022), kinaesthetic learners may require hands-on activities or manipulatives to understand geometric principles.

Educators need to take into consideration this, hence the use of strategies, including visual aids and different teaching methods, should be incorporated to accommodate learners with different learning needs (Noon, 2024). This can help facilitate an effective use of these visual aids and enhance further developments in the understanding of learners regarding concepts of geometry during the Grade 7 level of their learning. There are difficulties in the process of working out answers by using such visual aids for the geometry lesson. In fact, such situations of challenges cannot be entirely averted but appropriate use on the part of instructors by being sensitive to them should be undertaken in relation to the targeted learning (Baydas & Yilmaz, 2018). The discussed literature has shown some benefits and possible setbacks that using visual aids in teaching geometry to Grade 7 learners may have, thereby adding to this study's interest in their effect.

Geometrical concepts are very abstract and therefore diagrams, models and animations are vital in facilitating clearer understanding (Boyer, 2004; Dlamini & Nkambule, 2020). However, these aids must be carefully designed to avoid cognitive overload and confusion, specifically considering the cognitive development and limited prior knowledge of Grade 7 learners (Oji, 2024). The literature cautions against the over-reliance on visual aids, which can lead to passive learning and hinder the development of critical abstract reasoning and problem-solving skills (Ashikuzzaman, 2024; Yaffe, 2019). Moreover, resource constraints in some educational settings may limit the availability and quality of visual aids, hence requiring creative solutions and professional development for educators (Cansoy & Turkoglu, 2022; Mizell, 2010). The effectiveness of visual aids also depends on individual learning styles; therefore, educators should use a variety of teaching methods through to visual aids to meet the needs of all learners (Boyer, 2004; Glynn, 2022; Noon, 2024). Moreover, by addressing these challenges and incorporating visual aids in a thoughtful manner, educators can enrich learning and enhance the understanding of geometric concepts in Grade 7 learners. This holistic understanding of the strengths and weaknesses of visual aids assisted in achieving the purpose of this study on their effectiveness in teaching practices.

2.3. THEORETICAL FRAMEWORK

In the realm of using visual aids for Grade 7 geometry learners, the choice of research paradigm profoundly influences the approach to understanding reality, knowledge acquisition and the methods employed for comprehending the said reality. Thus, in the context of Grade 7 geometry instruction in this study, constructivist paradigm delineates fundamental assumptions about the nature of reality (Ponte et al., 2023). It further informs the pedagogical strategies employed especially when it comes to the use of visual aids to facilitate learning. In addition, the constructivist stance supports a framework that values diversity, interaction and qualitative understanding which are essentially all for effective use of visual aids in the learning process.

The constructivism perspective in education highlights on the socially constructed nature of knowledge and supports the understanding of how learners make meaning of mathematical concepts within specific contexts (Saunders et al., 2019). Duval's theory of semiotic representation aligns with this paradigm by offering a lens to explore how learners internalise mathematics through multiple representational systems. According to Duval (1995; 2003; 2017), understanding in mathematics arises from coordinating symbolic (e.g., notation), iconic (e.g., diagrams) and indexical (e.g., gestures, contextual references) representations. This theoretical framework supports an interpretivist inquiry into how learners construct meaning in geometry through representational fluency. As such, Duval's theory of semiotic representation is a detailed framework that offers understanding on how learners convey, comprehend and internalise mathematical concepts (Duval, 1995; 2003; 2017). Duval stated that mathematical knowledge is conveyed not only through symbolic representations like mathematical symbols and notation, but also through iconic and indexical representations. Iconic representations, such as diagrams, graphs and geometric shapes, help in visualising abstract mathematical concepts (Duval, 1995; 2003; 2017). Indexical representations, in contrast, are reliant on context and encompass gestures, spoken descriptions and real-life instances that connect mathematical concepts to tangible scenarios. Table 2.1 illustrates the characteristics and roles of symbolic, iconic and indexical representations as outlined by Duval (1995; 2003; 2017). Table 2.1 shows how each type of representation has a different function in the transmission and apprehension of mathematical knowledge, as Duval proposed. These representations interact with one another to enhance the learning process and understanding by providing multiple pathways to comprehend abstract mathematical ideas.

Table 2.1

Symbolic, Iconic and Indexical Representations

Representation Type	Description	Examples	Role in Mathematical Knowledge
Symbolic	Uses formal symbols and notation to convey mathematical ideas.	Mathematical symbols (e.g., +, -, ∫), equations, algebraic expressions.	Provides a precise and concise way to communicate abstract mathematical concepts and operations.
Iconic	Employs visual elements to represent mathematical concepts.	Diagrams, graphs, geometric figures, charts.	Assists in visualising and understanding abstract concepts through concrete visual means.
Indexical	Relies on context-dependent representations that link mathematics to real-world situations.	Gestures, verbal explanations, real-world examples, situational context.	Connects abstract mathematical ideas to tangible, real-world contexts, facilitating comprehension and application.

Adapted from Duval (1995; 2003; 2017)

The importance of Duval's theory of semiotic representation is in recognising that learners hold multiple ways of perceiving and understanding the mathematics themselves. Mathematics in and of itself is an abstract branch of knowledge which requires active representation to support learning. According to Ponte et al. (2007) and Davis et al. (2012) among other scholars, using of different representations allows for an understanding and acquisition of knowledge at younger ages when children cannot see beyond concrete ideas. Fractions are one of the most complex concepts to handle for both educators and learners, hence their teaching and learning calls for tact. Through incorporating multiple semiotic systems, educators can address a range of different learning styles and preferences among learners. For example, iconic representations support visual learners in building mental models of abstract mathematical objects; other learners may learn best through verbal explanations and discussions. Moreover, indexical representations offer contexts and relevance that give reason to mathematical knowledge and enhance understanding and engagement.

In practice, Duval's theory of semiotic representation has implications for educators to make use of different teaching strategies that rely on modes of representation. This can include using diagrams and visual aids during instruction, encouraging discussion and explanation from learners and providing examples in the real world to illustrate more abstract concepts (Duval, 1995; 2003; 2017). Furthermore, by integrating these different representations, it allows the educator to offer a deep learning environment that would improve the understanding, problem-solving skills and overall mathematical proficiency of the learners (Ferretti et al., 2024). Semiotic representation in mathematics learning has been broadly identified to range from being external, internal, conscious and non-conscious (Ferretti et al., 2024). External representation involves diagrams and symbols which help to communicate and allow the visualisation of mathematical concepts. Conscious representations involve intentional discovery and objectivation of ideas, contributing to deeper understanding. Duval's semiotic representation theory outlines various forms of representation, such as natural language, algebraic writing systems, geometric figures and graphs, each offering distinct perspectives on mathematical objects (Duval;1995; 2003; 2017). This suggests that effective geometry learning depended on learners' ability to interpret and convert among these representational forms, so that visual figures, language and symbols jointly supported conceptual understanding and problem-solving rather than operating in isolation.

Furthermore, Duval's theory of semiotic representation emphasises the significance of consistency and congruency within various semiotic. This implies that educators must make sure that symbolic, iconic and indexical representations support each other and remain coherent, allowing for smooth shifts between different modes of representation. Duval extensively discussed how coherence improves learners' ability to build concepts holistically and transfer understanding across different contexts. Given this, Duval's theory of semiotic representation provides useful perspectives on the intricate process of learning mathematics and emphasises the significance of using a varied approach in teaching mathematics. Educators can make learning experiences more inclusive, engaging and effective for all learners by acknowledging and using the various forms in which mathematical knowledge can be displayed. Figure 2.1 shows how Grade 7 geometry educators use various forms and types of visual representations, as outlined by Duval (2017). Different types of representations play a specific role in conveying and understanding mathematical concepts, as described by Duval. The interaction between these representations enhances learning and understanding by providing various ways to comprehend intricate mathematical concepts.

Duval's theory of semiotic representation is important because it acknowledges the various ways learners interpret and understand mathematical concepts (Duval, 1995, 2003, 2017; Viseu et al., 2021). Mathematics, being conceptual in essence, needs efficient depiction to assist comprehension. Multiple scholars highlight the significance of using various representations to assist learning, particularly in the early stages when children depend on tangible concepts (Davis et al., 2012; Ponte et al., 2007; Viseu et al., 2021). Fractions are difficult for both educators and learners because of their complexity, necessitating a thoughtful approach to education. Educators can address different learning styles and preferences among learners by using a combination of different semiotic systems (Duval, 1995, 2003, 2017; Viseu et al., 2021). Visual learners may find iconic representations very helpful, aiding in visualising abstract mathematical concepts, whereas auditory learners may favour verbal explanations and discussions, for example. Furthermore, indexical representations offer context and importance to mathematical ideas, leading to a more profound comprehension and involvement.

According to Duval's theory of semiotic representation, educators should rely on different teaching methods which are based on the use of different forms of representation (Duval, 1995, 2003, 2017). It can be presented by a means of visual aids and diagrams in teaching, learner conversations and explanations, offering concrete examples to clarify complicated ideas. By integrating multiple representations, the educator can create a vibrant learning environment that enhances the learners' conceptual understanding, problem-solving skills and overall mathematics competence (Duval, 1995, 2003, 2017). Semiotic forms of representation-external, internal, conscious and non-conscious play an important role in learning mathematics. Diagrams and symbols are modes of external representation that help in communicating and visualising mathematics ideas. Conscious representations are the intentional procession of something and externalisation with meanings for better understanding. Accordingly, Duval’s semiotic theory of representation expresses at least four different forms-namely, natural language, algebraic writing system, geometric figures and graph-presenting different visual realisations about mathematical objects, stated as Duval’s theoretical frameworks (Duval;1995;2003;2017). Also, this suggests that mathematical understanding was strengthened when learners were systematically supported to interpret and convert across these registers, rather than engaging with each representation in isolation.

Duval’s theory of semiotic representation was applied in this study to conceptualise how Grade 7 learners experience the learning of geometry when teaching deliberately integrates visual aids as more than illustrative add-ons. In geometry, understanding is built through different forms of representation. These include visual forms such as diagrams and sketches, symbolic forms such as formulas and notation, and contextual forms such as labels, arrows, and markings (Duval, 1995, 2003, 2017). Duval’s theory states that real understanding comes from connecting and moving between these forms, rather than relying on just one. This idea helps to analyse how learners understand geometry when visual aids are used in lessons (Duval; 1995; 2003; 2017).

Specifically, the pedagogical intent of visual aids in geometry is to stabilise spatial relationships and invariants. This enables learners to interpret properties such as parallelism, congruence, symmetry and angle relationships, in the diagram and then convert these observations into symbolic statements and deductive reasoning. Where such harmony is achieved, learners’ experiences are expected to reflect clearer sense-making, reduced cognitive load in interpreting diagrams and greater confidence in linking “what is seen” to “what must be proven” in geometric tasks (Duval; 1995; 2003; 2017). This positions visual aids as the mediating register through which learners’ geometric experiences were shaped, because their conceptual progress depended on being supported to translate systematically from visual inspection to formal symbolic justification.

When visual aids are used without clear guidance, learners may treat diagrams as images to copy instead of objects to interpret. This can cause confusion between what they see and the actual geometric properties, which weakens their reasoning and understanding (Duval; 1995; 2003; 2017). Figure 2.1 shows how often Grade 7 geometry teachers use different types of representations, especially visual ones, since these influence how learners develop their understanding of geometry (Duval; 1995; 2003;2017).

In this regard, the emphasis on educators' representational practices reflected the premise that learners' geometry outcomes depended less on exposure to visuals per se and more on whether teaching enabled disciplined translation from seeing to reasoning.

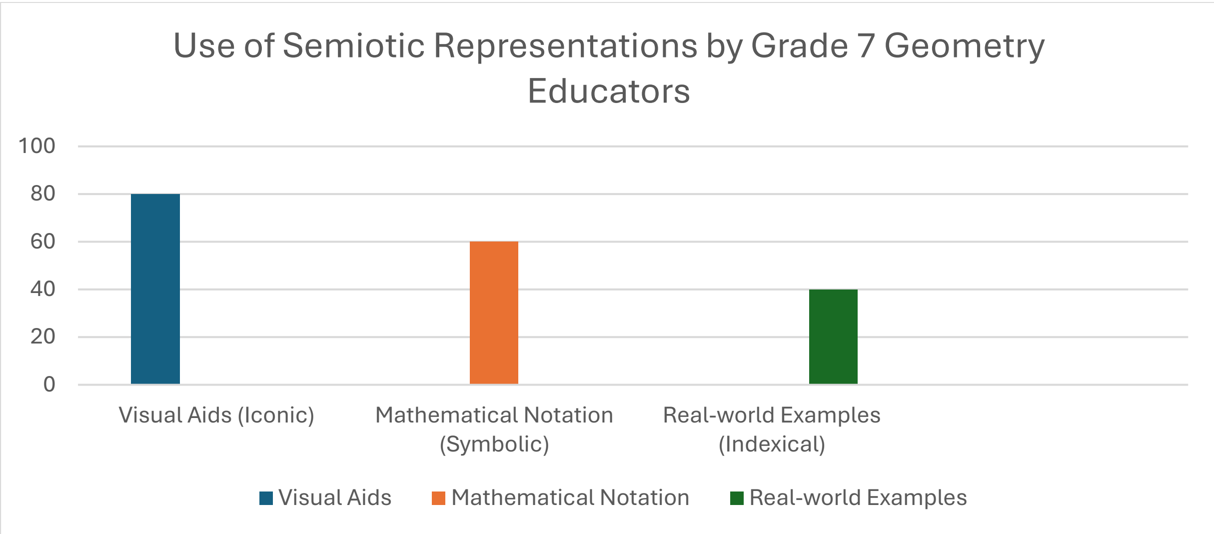

Figure 2.1

Use of Semiotic Representations by Grade 7 Geometry Educators

Source: Mainali (2021)

Duval's theory acknowledges that learning mathematics is not a simple process and requires a combination of factors to ensure the learners get it right (Duval;1995; 2003; 2017). Another important factor is the amount of professional development assistance that Grade 7 geometry educators receive in selecting, developing and implementing appropriate visuals (Mainali, 2021). Assessing these professional development measures can help determine whether the educators obtain the necessary competencies and knowledge to appropriately combine other semiotic systems with visual cues. This integration is critical because it helps deliver learning benefits to learners with different learning needs (Duval;1995; 2003; 2017). In light of these aspects, it is easier to establish the correlation between educator training and the application of visuals in geometry teaching (Smith & Cekiso, 2020). This indicates that the impact of visual aids in Grade 7 geometry was contingent on educators' professional capacity to orchestrate conversions across representations, making professional development a key condition for conceptual learning and equitable learner engagement.

Furthermore, it is possible to identify the multifaceted approach to analysing this category within the framework of the theoretical analysis given by Duval's theory of semiotic representation. Concerning the fit of icons, symbols, indices and ratios of visuals to other means as well as the professional development that can be offered to educators, this model presents valuable knowledge about how educators can teach more effectively. This gives this study a broad perspective when it comes to comprehensively explaining the impact of the visual aids on the learners' geometric learning experiences and academic success.

2.4 SYNTHESIS

2.4.1 Semiotic representation facilitation approach

The current study states that Duval's semiotic representation theory aligns with instructional guidelines for using visual tools in teaching geometry to yield the semiotic representation facilitation (SRF) approach. This study emphasises that the SRF approach denotes a facilitation strategy that applies semiotics, that is, signs and symbols to support learners to construct meaning and enhance communication. In addition, the SRF approach in this study refers to learners actively creating meaning through the interplay of symbols within context. Furthermore, this study emphasises the need for intentional and well-planned visuals that enhance comprehension, engagement and accessibility while being realistic about issues such as resource constraints and diversity among learners. Figure 2.2 shows how the SRF approach supports an integrated approach towards teaching using visual tools to impact on geometry learning.

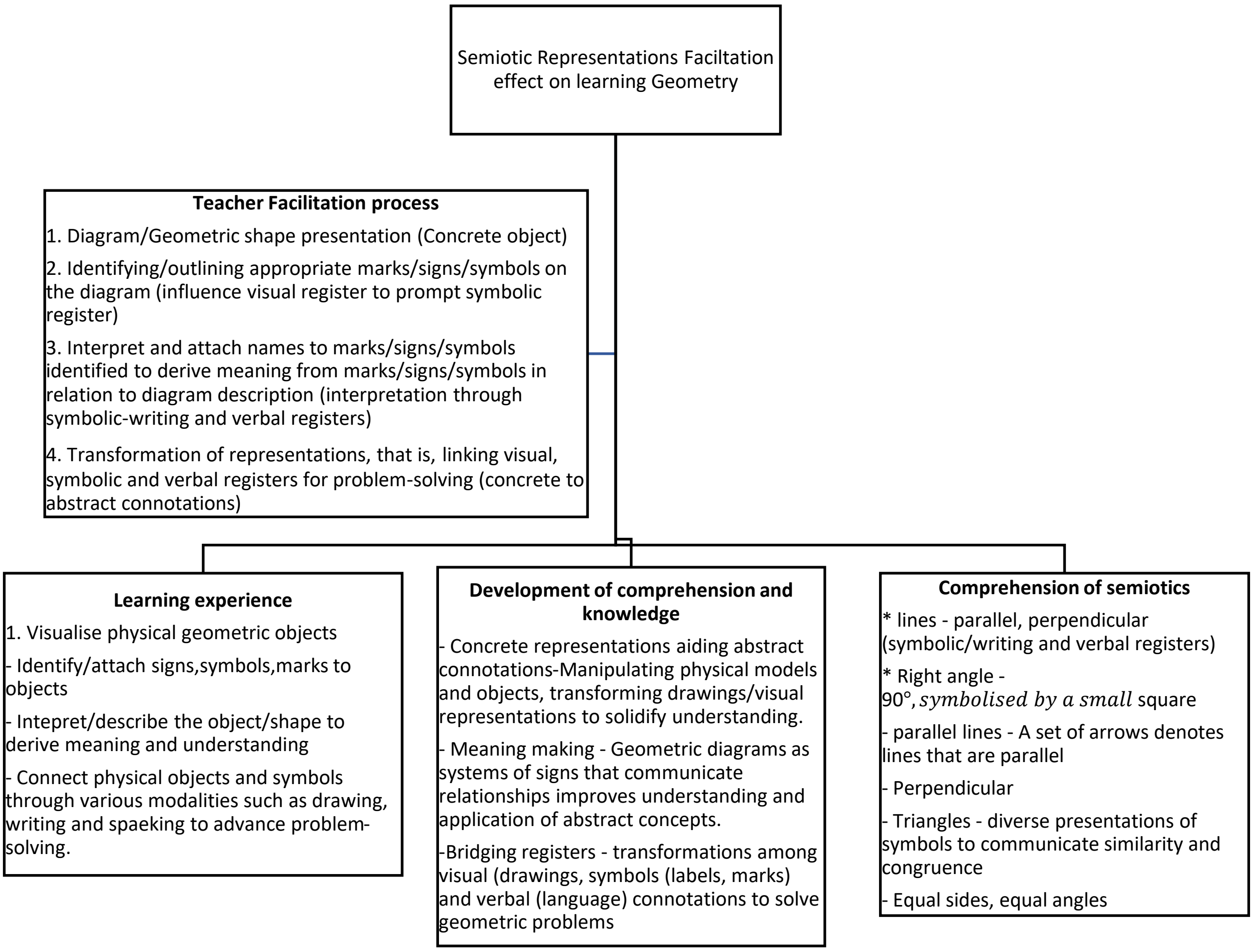

Figure 2.2

The impact of semiotic representation

Source: Author

Visual aids support Grade 7 geometry learning by linking teaching methods that use different representations with the knowledge and understanding that learners develop. Teachers deliberately incorporate symbolic, iconic and indexical representations into teaching in ways that reconcile content and learning objectives, so that visual aids augment as well as add to the curriculum. Symbolic representations, such as formulas and mathematical symbols, provide an abstracted and formalised language for the communication of abstract ideas but are meaningful only when supplemented by supportive representations. Teachers therefore use iconic representations such as charts, geometric shapes and diagrams to represent spatial properties and relationships visually, so that learners can form concrete mental images of abstract ideas. At the same time, indexical representations such as real-world pictures, gestures and context descriptions, root abstract theoretical geometric ideas in everyday experience, making them comprehensible and useful.

Through this mixture of semiotic systems, visual aids facilitate greater comprehension and memorisation, allowing learners to visualise complex geometric relationships and to align comprehension across representations, as Duval's (1995; 2003; 2017) emphasis on semiotic coherence would lead us to predict. Visual aids also enhance motivation and participation, since interactive and high-visual materials capture attention and construct effective learning by connecting geometry to life and everyday situations (Kristiawan & Kumalasari, 2023). This promotes hands-on and interactive learning, such as using 3D models or dynamic geometry software. It helps learners build knowledge actively and develop skills like spatial reasoning, problem-solving, and reflection (Anggo & Arapu, 2018; Dlamini & Nkambule, 2020). Further, by providing various modes of representation, visual aids aid differentiation and allow for differences in learner ability, levels of prior learning and learning styles, visual, auditory or kinaesthetic (Boyer, 2004; Oji, 2024). This makes more learners with a wider range able to contribute meaningfully to geometric material. Therefore, this study highlights that the impact of SRF approach on learning comprise enhanced retention.

This approach shows how teaching strategies based on Duval's theory use visual tools to improve understanding, interest, and key geometry skills. It provides a powerful optic for interrogating the way in which these dynamics operate within teacher interviews and teacher observation, directly relating theoretical explanations to empirical findings of Grade 7 geometry education.

2.5 CHAPTER SUMMARY

Although challenges like complexity and resource constraints persist, visual aids have proven effective in improving comprehension and application of concepts in geometry instruction. This study's theoretical framework, Duval's theory of semiotic representation, emphasises the importance of employing multiple modes of representation to cater to diverse learning styles. Moreover, by integrating various semiotic systems, educators can create a rich learning environment that enhances learners' comprehension and problem-solving skills. Coherence across different modes of representation ensures holistic understanding of mathematical concepts, showcasing the significance of Duval's theory of semiotic representation in promoting inclusivity and effectiveness in mathematics education. The next chapter addresses the research methodology of this study.

CHAPTER 3

RESEARCH DESIGN

3.1 INTRODUCTION

This chapter outlines the research design employed in this study. According to Cohen et al. (2018), a research design is a comprehensive plan that outlines the approach, theories, methodologies, data collection, data analysis, interpretation, reporting and validity & reliability of conclusions for investigation a research problem. In view of this, the research design in the current study includes an overview of the research philosophy, description of the research methodology, research approach, population under study and the sampling procedures implemented. Also, the data collection methods and process used are elaborated. This helps to provide insight into how research data was gathered for analysis. Furthermore, the chapter discusses the analysis method employed to interpret the collected data. Finally, ethical considerations are also addressed to ensure this study was conducted ethically, safeguarding the rights and well-being of participants throughout the research process.

3.2 RESEARCH PARADIGM

In this study, the interpretivist paradigm shaped the methodology by viewing learners' understanding of geometry as something developed through interaction with visual aids, teachers, and peers in the classroom. In line with the view that research paradigms shaped what counted as reality and knowledge, interpretivism treated the "reality" of learning geometry with visual aids as multiple and context-bound, rather than as a single, measurable outcome that could be detached from classroom conditions (Wagner et al., 2012; DeCarlo, 2018; Park et al., 2020). This assumption guided the study to use a qualitative approach. The study aimed to understand how learners interpreted diagrams, visual models, and other resources. It also examined how learners moved between concrete and abstract thinking in geometry and how classroom conditions influenced these experiences.

Data collection and analysis focused on learners' and teachers' perspectives and on what happens in real classrooms. This allowed the study to explain not only whether visual aids were used, but also how they were used and how learners understood them in relation to concepts such as shape properties, angles, symmetry, and spatial reasoning. In line with the interpretivist approach, the study focused on understanding learners' experiences rather than only measuring results. The goal was to explain how visual aids influence learning in specific classroom contexts (Bonache & Festing, 2020). Considering this, the interpretivism stance oriented the study toward methodological choices that privileged contextualised accounts of representational use and learner meaning making as the primary evidence for evaluating the pedagogical impact of visual aids in geometry.

3.3 RESEARCH METHODOLOGY

In the context of enhancing geometry instruction for Grade 7 learners through the integration of visual aids, the choice of research methodology plays a pivotal role in clarifying the intricacies of this pedagogical approach. Research studies in education typically adopt either qualitative, quantitative or mixed-methods research methodologies to investigate various phenomena within educational settings (Creswell & Creswell, 2018; Macmillan & Schumacher, 2014). While quantitative methodology focuses on quantifying data to make generalisations, qualitative research emphasises understanding phenomena deeply by extracting extensive data to elucidate meanings (Babbie, 2016). For examining the impact of employing visual aids in teaching geometry to Grade 7 learners, the qualitative research methodology emerges as the most appropriate and insightful choice.

Furthermore, the qualitative approach is ideal for thorough examinations when researchers intend to investigate topics with little existing information (Babbie, 2016). In the setting of instructing Grade 7, geometry learners with visual aids, the best methods for incorporating them and their influence on educational achievements may not be completely known (Jablonski & Ludwig, 2023). In this way, qualitative research provides an opportunity for initial investigation and finding. Researchers can obtain in-depth data by using techniques like observations, interviews and document analysis (Patton, 2023). In addition, collecting this information aids in gaining a comprehensive grasp of the various factors influencing the classroom setting.

Furthermore, a qualitative research methodology provides flexibility and adaptability, enabling researchers to customise their approach to the unique requirements and complexities of the research setting (Creswell & Poth, 2018). This adaptability is especially beneficial when investigating the impact of visual aids because it allows researchers to modify their approaches according to new findings and changing research inquiries. Nonetheless, the qualitative research methodology is a strong framework for studying how visual aids can improve geometry teaching for Grade 7 learners. Furthermore, it provides valuable knowledge that can enhance and shape teaching methods in mathematics instruction.

3.4 RESEARCH APPROACH

The use of visual aids in teaching Grade 7 geometry is a complex phenomenon that requires a research approach capable of delving into the essence of the experience from the perspective of those involved (Creswell & Poth, 2018). In this study, an interpretive phenomenology research approach was employed, and this approach aligns with the interpretivist research paradigm and qualitative research methodology. According to Neubauer et al. (2019), phenomenology seeks to describe the essence of a phenomenon by exploring it from the perspective of individuals who have experienced it. Unlike simply examining reactions to experiences, phenomenology uncovers the underlying meaning and essence of those experiences which in turn provides valuable insights into what is hidden behind them (Zhou et al., 2022).

Interpretive phenomenology focuses on interpreting and understanding the lived experiences of individuals within a specific context (Connelly, 2010; Neubauer et al., 2019). For this reason, the study used an interpretive phenomenology approach. This approach looks beyond surface observations to understand how Grade 7 learners make meaning of their experiences with visual aids in geometry. This approach was particularly well suited for studying pedagogical practices as it allows researchers to explore the subjective perspectives of learners and educators. Thus, uncovering the underlying processes and dynamics at play in the classroom.

Moreover, interpretive phenomenology is widely recognised and used across various fields including pedagogy, medicine and psychology (Zhou et al., 2022). Its applicability in diverse research contexts underscores its effectiveness in uncovering rich and nuanced insights into human experiences. In the context of exploring the use of visual aids in teaching Grade 7 geometry, interpretive phenomenology provides a comprehensive framework for understanding how learners perceive, interpret and engage with these instructional tools. Therefore, this qualitative research embraces participants' subjective interpretations and experiences to holistically explore Grade 7 geometry instruction complexities and advance mathematics education pedagogy.

3.5 RESEARCH INSTRUMENTS

This study used interviews and observations to engage with participants. Using a combination of interviews and observations offered a comprehensive approach towards examining the intricate process of using visual aids in teaching Grade 7 geometry. Interviews gave a glimpse into participants' views, beliefs which are the understandings, assumptions, or propositions that shape teachers' instructional decisions and classroom practices (Ramnarain & Ncube, 2023), and interactions; on the other hand, observations provided a contextual grasp of how visual aids are truly used in the classroom environment. In combination, these techniques offered a comprehensive understanding of the teaching strategies and how they affect learners' educational achievements. Therefore, using both interviews and observations provided a strong method for collecting detailed and varied data. This ultimately assisted in enhancing comprehension of the effectiveness and difficulties related to incorporating visual aids in Grade 7 geometry teaching. However, adding classroom observations to interview data helped the researcher to validate findings and improve this study's trustworthiness.

3.5.1 Observations

Observations were used as another important source of information in the current study. They offered a first-hand and unfiltered view of classroom dynamics which allowed the researcher to gain insights that may not be readily apparent through interviews alone (Morgan et al., 2016). In this regard, observations gave the researcher a personal understanding of the situation, capturing aspects of teaching and learning that participants might not discuss or notice. Nonetheless, the observations were done during normal class hours for a duration of one hour for seven separate days with each participant. Moreover, the researcher acted as a non-participating observer, and this was done to minimise disruptions from the researcher that may influence the behaviour of learners in a way that would not normally happen during unsupervised classroom lessons.

Non-participant observation can help the observer to remain neutral and objective allowing observation data to be collected as accurately as possible (Ciesielska et al., 2018; Hofmeister, 2021). Furthermore, non-participatory observations enabled the researcher to collect data on the actual use and effectiveness of visual aids in the classroom without influencing the dynamics. Non-participatory observation method provided an unbiased account of how visual aids are implemented and how Grade 7 learners interact with them which was valuable for this study. In view of this, observations can reveal practical challenges and successes in real time which offers a grounded understanding of the visual aids' impact on learners' engagement and performance in geometry.

The classroom observations schedule investigated the impact of teaching using visual aids on learning in alignment with the classroom environment; how the educator introduced the lesson, available visual aids and how they were used (Appendix G). Each item in the observation schedule focused on how visual aids were used in teaching geometry. It recorded the classroom context, how teachers introduced these tools and how they were applied during lessons. This helped show their effect on learners' engagement, understanding and overall learning experience. This systematic focus enabled a clear exploration of how visual aids shaped learners' cognitive and motivational responses to geometry instruction.

3.5.2 Interviews

Bhasin (2019) identifies three types of interviews: structured, semi-structured and unstructured. However, semi-structured interviews were used in this study to incorporate structured and unstructured formats by relying on pre-set questions while also allowing the researcher to develop emerging themes and probe for more detailed responses (Adeoye-Olatunde & Olenik, 2021). The semi-structured interview was considered appropriate for this research as it allowed for a thorough investigation of participants' experiences and viewpoints on the impact of visual aids in Grade 7 geometry teaching. Moreover, the semi-structured interviews were successful in comprehending Grade 7 geometry learners' and educators' views on visual aids. Furthermore, semi-structured interviews provided valuable insights into how visual aids affect the engagement, comprehension and geometry skills of Grade 7 learners, aligning closely with the goals of this study.

The questions were integral to the research objectives as they explore educators' understanding, experiences and criteria for using visual aids which offered insights into how these tools influence Grade 7 learners' geometry skills. They provided qualitative data on the experiential impact of visual aids on learners' comprehension and engagement, indirectly capturing learners' experiences with these tools. Questions about the selection criteria and the influence of quality directly inform suggestions for identifying high-quality visual aids. Furthermore, inquiries into the educator's training contextualise their practices, while open-ended responses may reveal overlooked factors, aligning the data with this study's aim to enhance geometry instruction through effective visual aids. The interview guide for this study is provided in Appendix H. Furthermore, the interview items align with this study's purpose of exploring how the utilisation of visual aids in teaching geometry enhance the grade 7 learners' geometric learning experience. Furthermore, the interview items elicited background information on teachers' profiles and training, their knowledge and practice of visual aids, the determinants of their choice and their perception of the quality of the aids and their impact on learners. This framework grouped responses into themes such as teacher context, use of visual aids, and their impact on learners' understanding and engagement. This helped the study examine how visual aids influence learning and classroom experiences in geometry.

3.6 TARGET POPULATION

Saunders et al. (2016) define a target population as the entirety of elements that a researcher intends to study within a population. This population shares certain similarities to a certain extent. The accessible population, as described by Fetzer (2020) and Scott and Garner (2013), refers to the subset of elements within the target population that the researcher can readily access. Pinetown District of Durban, South Africa has 98 schools and about 2 940 educators. The target population for this study was Grade 7 geometry teachers in these schools.

3.7 SAMPLING STRATEGY

The process of sampling can be categorised into probability and non-probability methods as outlined by Showkat and Parveen (2017). Probability methods involve the selection of a representative sample through randomisation, increasing the likelihood of generalising findings to the larger population (Marwill & Rossman, 2014;

Showkat & Parveen, 2017). However, this method is more suitable for studies with large sample sizes; where analysing each sample individually may be less practical. In contrast, non-probability sampling methods do not select samples randomly; instead, samples are chosen based on the researcher's judgement of their importance and contribution to this study (Salkind, 2011; Showkat & Parveen, 2017). Considering this, the researcher used non-probability purposive sampling to select Grade 7 geometry educators from the target population, as it was considered appropriate for this study. Non-probability purposive sampling consists of choosing participants according to particular criteria that are pertinent to the research being conducted (Palinkas et al., 2015). In this situation, Grade 7 mathematics educators were specifically selected because of their knowledge, teaching experience and proximity to the researcher. This ensured that the chosen sample would offer useful insights into the use of visual aids in teaching Grade 7 geometry. Therefore, using purposive sampling is in accordance with the specific goals of this study and enabled the inclusion of individuals who had the relevant expertise and viewpoints to make valuable contributions to the research. This study included a sample size of six participants who were selected from the target population. The six participants were mathematics teachers from six primary schools in the Pinetown district.

3.8 DATA COLLECTION PROCEDURES

All the participants who were invited to take part in this study accepted the invitation. The interviews and observations were scheduled to occur on the same day. Observations were done before interviews to help the researcher understand the environment, social interactions and non-verbal behaviours that participants may not mention in the interviews. However, several participants spoke English as a second language, requiring additional time for the researcher to clarify and simplify questions to elicit appropriate responses. Moreover, two participants were on sick leave on the initially scheduled day, requiring the rescheduling of their interviews and observations later in the week. This adjustment led to the revision of the researcher's data collection timeline. To preserve the natural classroom setting and to minimise the extent to which interview discussions might prime participants' enactment of visual-aid practices, classroom observations were conducted first. Thereafter, semi-structured interviews were conducted second to elicit educators' reflections and rationales after their lessons.

Observations were conducted concurrently, using an observation schedule (Appendix G) to systematically document key aspects of classroom interactions. The observation schedule focused on specific criteria such as the use of visual aids during each phase of the lesson, their relevance, clarity, explanatory impact, integration with the lesson content and ability to foster learner interest. Furthermore, the researcher documented educator engagement strategies and overall classroom dynamics, summarising key observations at the conclusion of each session to assess the effectiveness of visual aids in facilitating the comprehension of geometry. On the other hand, interviews were conducted face-to-face at the respective schools, guided by an interview schedule (Appendix H). During the interviews, the Samsung voice recorder application on the researcher's cell phone was used to record responses for accuracy and subsequent analysis.

Despite the logistical challenges encountered, the data collection process successfully captured a strong dataset through interviews and structured observations. This enabled a comprehensive analysis of the pedagogical strategies employed by the participating educators.

3.9 DATA ANALYSIS

In this study, thematic data analysis was employed as a suitable approach for analysing data gathered from semi-structured interviews and observations related to the use of visual aids in teaching Grade 7 geometry. Furthermore, this study used Braun and Clarke's (2019) method for thematic data analysis, involving six stages:

i) becoming familiar with the data;
ii) creating initial codes;
iii) developing themes;
iv) examining possible themes;
v) defining and labelling themes; and
vi) compiling the report (Byrne, 2022).

This approach helped with systematically recognising common themes and patterns in qualitative data as described by Braun and Clarke (2019). Furthermore, by analysing code, the researcher found information on how effective visual aids are in the classroom, the difficulties in using them and the sociocultural factors that impact teaching methods. Thematic data analysis can lead to a more thorough investigation of intricate connections and unique characteristics among learners, potentially enhancing knowledge in Grade 7 geometry instruction (Braun & Clarke, 2019).

3.10 TRUSTWORTHINESS

Trustworthiness of this study was achieved through several key strategies which included adhering to the quality criteria of credibility, transferability, dependability and confirmability. Credibility refers to the extent to which the findings accurately represent participants' experiences and are considered believable. Transferability concerns the extent to which the findings can be applicable to other contexts through the provision of rich, detailed descriptions. Dependability relates to the consistency and stability of the research process over time, enabling the study to be repeated under similar conditions. Confirmability refers to the degree to which the findings are shaped by the participants' experiences rather than researcher bias or personal assumptions (Korstjens & Moser, 2018). Considering this, to attain credibility in this study, the researcher employed prolonged engagement which involved spending sufficient time in the field by visiting the schools and teachers prior to conducting interviews. This was done to build trust and gain a deep understanding of the context which helped the researcher to collect rich data (Korstjens & Moser, 2018). Triangulation was achieved through employing two data collection methods such as semi-structured interviews and non-participatory observations. Existing literature was used to corroborate the research findings. In addition to this, the researcher also allowed the participants to review and validate the data and its interpretation to ensure that it was captured accurately and aligned to their perspective.

The researcher ensured transferability of the research results by offering detailed descriptions of the research setting, participants and procedures. Providing a thorough explanation of the research methodology enables fellow researchers to assess the generalisability of the results to various settings or populations (Korstjens & Moser, 2018; Moon et al., 2016). This study outlined the Grade 7 geometry teaching environment, which encompassed participant demographics, visual aids and observed instructional methods. The research process also ensured dependability through the maintenance of an audit trail. This involved thorough documentation of the research process and the procedures for collecting and analysing data.

Furthermore, this also permitted the researcher to maintain a clear and corroborated research procedure and outcomes. Peer debriefing, which involves discussing the research process and emerging findings with knowledgeable colleagues who critically question interpretations and challenge potential biases to enhance the rigour and trustworthiness of the study, was used alongside regular discussions to assess the consistency of the results (Korstjens & Moser, 2018; Nowell et al., 2017). In this regard, thick description, which involves providing rich, detailed accounts of the research setting, participants, and context to enable readers to determine the applicability of the findings to other settings, and an audit trail, which entails maintaining a comprehensive and transparent record of the research process and methodological decisions to demonstrate the consistency and dependability of the study, were used to enhance the study’s trustworthiness by enabling informed judgement of applicability and by demonstrating methodological consistency.

Lastly, confirmability was established by showing that the results were based on the information gathered and not by the biases or preconceptions of the researcher. This was verified by using reflective journals where the researcher noted down his thoughts, beliefs and choices during the research. The audit trail also helped to enhance confirmability by showing evidence of the data analysis process and decisions made during this study (Connelly, 2016; Korstjens & Moser, 2018). Considering these above-mentioned tactics, this study successfully maintained a thorough and reliable research process while examining the effectiveness and difficulties of using visual aids in Grade 7 geometry instruction, along with the societal and cultural aspects impacting teaching methods.

3.11 ETHICAL CONSIDERATIONS

A systematic approach was used during the data collection process to guarantee adherence to institutional protocols and active involvement of participants. The researcher followed the ethical guidelines of the UNISA. Approval of the ethical committee was availed to the researcher by the College of Education research ethics committee (See Appendix A). Approval was requested and received from the KwaZulu-Natal Department of Basic Education to carry out the research (See Appendix B).

After obtaining this authorisation, six schools were contacted telephonically to make arrangements for the data collection process. School principals were approached to seek permission to conduct research at schools (See Appendix B). Once agreements were reached, suitable dates and times were established for conducting interviews and observations. All six invited schools agreed to participate and the respective principals and educators co-ordinated with the researcher to accommodate the data collection schedule. Consent and assent letters were then taken to the respective schools to be filled in by participating educators (See Appendix C) and learners (See Appendix E). Parental consent was also obtained from parents of learners who were participating in the research (See Appendix D).

However, in conducting semi-structured interviews and observations, a researcher is expected to observe several ethical concerns that protect the rights and welfare of participants. The participants gave informed consent and engaged in the research study willingly after understanding the purpose and aim of the research and this was assured by the researcher. Moreover, in academic research, confidentiality must be ensured and the researcher obtained appropriate measures to ensure that confidentiality would be maintained for the respondents. This was accomplished by protecting all personal information disclosed in interviews and observations. Furthermore, the researcher made sure that the participants' anonymity was protected to prevent their identities from being disclosed. As such, adhering to these ethical considerations ensured that the researcher conducted this study responsibly and with the utmost respect for the rights and dignity of participants.

3.12 CHAPTER SUMMARY

This study aligns with the interpretivist paradigm that supported the qualitative methodology to explore the use of visual aids in Grade 7 geometry instruction through interpretive phenomenology, employing interviews and observations for data collection. Semi-structured interviews and non-participatory observations provided a comprehensive understanding of teaching dynamics, while thematic analysis uncovered patterns and insights from the data. Trustworthiness was ensured through credibility, transferability, dependability and confirmability with rigorous adherence to ethical guidelines to protect participants' rights and well-being. The sample of this study were six participants which were selected from a target population of Grade 7 geometry educators within the Pinetown District of Durban. The next chapter discusses the data analysis and findings of the research study.

CHAPTER 4

PRESENTATION OF THE RESEARCH FINDINGS

4.1 INTRODUCTION

This chapter reports the findings from the demographic data, observations of teacher learner classroom interactions and interviews.

4.2 DEMOGRAPHICS OF THE STUDY

This section outlines the demographic profile of the six participants according to their age, gender, experience and highest educational qualifications. These factors play an important role when analysing their experiences with the use of visual aids in geometry lessons. The age of the participants ranged between 30 and 62 years, while the years of teaching at Grade 7 mathematics were between one and over 40 years, as shown in Table 4.1.

Table 4.1

Demographics of Participants in the Study

Participant ID	Age	Gender	Experience	Highest Educational Qualification
P1	56 years	Female	34 years	Bachelor of Pedagogics in Primary Education Degree
P2	42 years	Male	11 years	Bachelor of Arts in Education Degree
P3	62 years	Female	40 years	Bachelor of Arts in Education Degree
P4	54 years	Female	4 years	Diploma in Education Degree
P5	59 years	Female	20 years	Bachelor of Arts (Honours) in Education Degree
P6	35 years	Female	1 year	Master of Education Degree

The demographic profile of the age, Grade 7 geometry teaching years and highest education level of the participants in this research was diverse in nature, as seen in the contributions to the research. The participants with experience more than 20 years such as Participant 1, Participant 3 and Participant 5, gave detailed responses in the context of pedagogy and the need for improved visuals to learn. Furthermore,

they witnessed changes in teaching methodologies, curriculum reformations and augmented use of technology over time. Their extensive experience also enabled them to offer remarks on the long-term impact of visual aids on learners' learning and enthusiasm.
Mid-career participants, such as Participant 2 with 11 years of experience, provided an equal perspective between older and newer practices in teaching. The participant would likely be representative of the continuing emphasis on professional development workshops and departmental support for the incorporation of visual aids in geometry classes. His perspectives were particularly revealing about how recent educational policy and teacher training programmes had impacted the use of visual aids. Simultaneously, the newer members of staff such as Participant 4 and Participant 6 brought in new thinking, likely following the latest teaching courses with their emphasis on recent pedagogies. Their relatively new appointment as teachers provided evidence of how the visual aids, specifically digital interactive aids, reflecting their growing accessibility.

The participants' educational qualification also broadened the scope of perceptions they undertook in research. These ranged from the completion of Bachelor and Master of Education degrees, thus exhibiting considerable variation in educational background. Teachers were marked as qualified to teach mathematics. This contributed to their theoretically and research-informed responses including using technology and some teaching methodologies through visual aids. At the same time, professional in-service training equipped them with more expertise to use visual aids practically, particularly in classrooms with limited resources.

Therefore, the convergence of these diverse experiences, qualifications and teaching environments added significant depth to this study. The variation in teaching experience provided both established and current insights, while the variation in educational backgrounds ensured that this study captured both practice and research-based approaches to the use of visual aids. The presence of participants from different socio-economic teaching environments also ensured that this study provided an overall view of how visual aids were selected, adapted and used in different education environments. This plurality of perspectives was crucial to answer the wide range of visual aids' impact on Grade 7 geometry learning because it allowed this study to address variations in instructional approaches, learning needs and resources.

4.3 OBSERVATION FINDINGS

Observation was used in exploring teacher-learner and learner-learner interactions during geometry lessons. The following observation items were considered: geometry classroom environment, teaching strategies in using visual aids, learner engagement through use of visual aids towards content acquisition.

4.3.1 The geometry classroom environment

The geometry classroom environment was observed with a focus on accessibility and use of learning material in the form of visual aids to engage learners in a geometry-resourced classroom. The available visual aids were scrutinised with a focus on their types, alignment with lesson content, relevance, clarity, explanatory effectiveness, integration into instruction, and their potential to enhance learner interest. The relevance of visual aids refers to how well they connect to the geometry content. Clarity means they do not cause confusion. Explanatory effect refers to how they support understanding. Integration shows how well they fit into the lesson. Interest in this study, refers to their ability to engage learners. Table 4.2 outlines the visual aids material that were available and accessible in conjunction with the teachers' practices in using these types of visual aids for teaching geometry.

Table 4.2

Summary of Vignettes

Participant 1 used a wall chart (2D diagrams) to illustrate various types of angles (cf. Appendix I, Vignette 1); complemented this with manipulating a cardboard for creating 3D material and used hinged stick models (3D) to support learners to physically explore angle sizes. In addition, Participant 1 used animated slide presentation created in PowerPoint to model angles' transition in sizes (Appendix I, Vignette 7).
During Participant 2's class sessions, the teacher cut a paper to create flat 2D shapes and facilitated the creation of 3D shapes (Appendix I, Vignettes 2.1 and 2.2).
Participant 3's lesson focused on types of angles and measuring the magnitude of angles using a protractor, using a chart to demonstrate how to use the protractor to explore the types of angles and their sizes (Appendix I, Vignette 3).
In Participant 4's lesson, worksheets were used to teach perpendicular and parallel lines, including using the set square to sketch perpendicular lines (Appendix I, Vignette 4).
Participant 5 presented a lesson about lines, using a chart to demonstrate types of straight lines (Appendix I, Vignette 5).
Participant 6 used PowerPoint presentation to present and explain concept and a video to display transformation through rotation.

Teacher practices show that the visual aids that teachers could access and use in their classrooms include charts or posters; hinged stick models; PowerPoint presentation, 2D and 3D shapes; manipulatives such as mathematical instruments (for example, protractor and set squares) and videos. The use of these resources (Figure 4.1) supports exploration, visualisation and the connection between concrete and abstract geometric concepts.

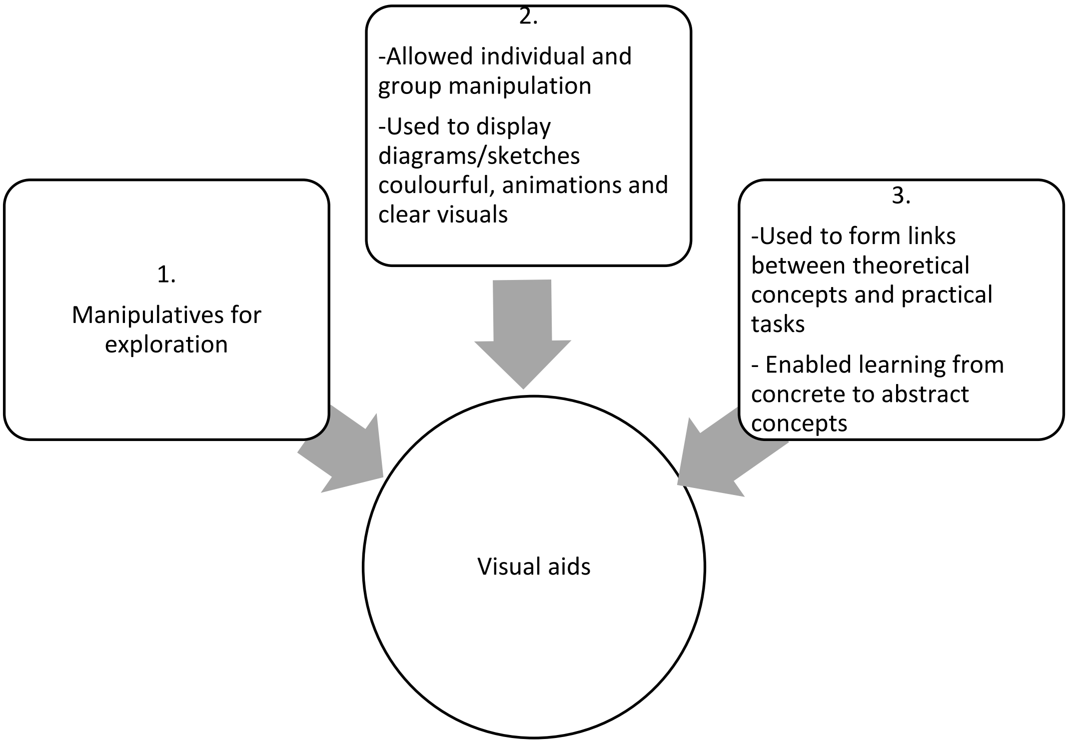

Figure 4.1 Visual Aids

Within the observed geometry classroom environment, the available and accessible visual aids enabled teaching strategies that include demonstrations, clearer explanation of geometric concepts and learner-centred contexts. Furthermore, the relevancy, clarity, explanatory effect and integration skills in the types of visual aids that were accessible are reported in Table 4.3.

Table 4.3

Accessibility and Use of Visual Aids in Teaching Geometry

	Type of visual aid used	Relevancy	Clarity	Explanatory effect	Integration
P1	• Wall chart; hinged stick models; PowerPoint presentation through animation.	• Demonstration of types of angles. • Learner active engagement through manipulation. • Learner visualisation of types of angles.	• Accuracy of figures and neatness of sketches.	• Concepts alignment with sketches for clearer explanation. • Support concept explanation with relevant visuals.	• Multimedia integration; digital PowerPoint (text and sketches).
P2	• 2D and 3D paper shapes.	• Demonstration and exploration of characteristics of two and three-dimensional shapes.	• Accuracy and neatness. • Comparison of 2D and 3D shapes.	• Concepts aligned with characteristics of a square, square pyramid and cube.	• Integration of handmade paper models with sketches.
P3	• Chart (Angles) • Mathematical instrument (protractor).	• Types of angles. • Classifying angles based on sizes. • Measuring sizes of angles.	• Accuracy and neatness of figures with reference to sizes.	• Concepts aligned with types of angles. • Use sizes to classify and compare angles.	• Chart (text and sketches) and protractor (manipulative).

P4	• Worksheet (text). • Mathematical instruments (set squares).	• Demonstration and exploration of parallel and perpendicular lines. • Comparison of sets of lines.	• Accuracy and neatness of sets of parallel and perpendicular lines.	• Concepts aligned with parallel and perpendicular lines. • Comparison the sets of lines.	• Integration of worksheet (text and sketches) with set squares (manipulative).
P5	• Chart	• Demonstration of types of lines.	• Accuracy and neatness of types of lines.	• Concepts aligned with different lines.	• Integration of text with sketches.
P6	• PowerPoint (text and sketches). • Video (text, audio and diagrams / sketches).	• Explanation and demonstration of rotation of shapes.	• Accuracy and neatness of figures and images.	• Concepts aligned with rotation of figures to build images.	• PowerPoint (text and sketches) • Video (text, audio and diagrams / sketches).

Accuracy and neatness of diagrams was maintained through use of resources that integrated text with the visual aids in forms of diagrams/sketches and manipulatives. On one end, the visual aids used by participants were directly linked to the geometry content being taught, such as types of angles, lines and shapes and served to concretise abstract mathematical concepts. In addition, teachers effectively used these aids to provide factual and conceptual clarity by illustrating relationships, properties and processes, thereby supporting learners' comprehension of geometric principles.

4.3.2 Teaching strategies enabled through visual aids

The explanatory effect as indicated in Table 4.3 emphasises that the accessible visual aids enabled practical explanations, where explaining concepts aligned with views of symbols, sketches, animations and pictures. In addition to explaining concepts, teaching strategies were aligned with the use of visuals. Table 4.4 shows the strategies that matched the visual aids available to teachers.

Table 4.4

Teaching Strategies supported using Visual Aids

Participant 1 Illustrated and explained various types of angles. Engaged learners to explore angle sizes. That is, facilitation through demonstration, illustration and explanation towards learner-centred lesson for exploration of the types of angles
Participant 2 Demonstrated 2D and 3D through activity of cutting, folding, drawing and creating. Engaged learners in using drawing and cutting paper to explore the square and folding to create 3D shapes and explore the sides of both a cube and a square pyramid. Manipulation of learning material towards learner-centred lesson to develop learner creativity skills to support the development of spatial sense.
Participant 3 Using a chart to demonstrate the types of angles and their measurement; illustrate how to measure the magnitude of angles using a protractor (Cf Appendix I, Vignette 3). Engage learners in discussions to analyse the magnitude of angles to distinguish among the types of angles.
Participant 4 Used worksheets with illustrations to display and explain perpendicular and parallel lines. Demonstrate and engage the learners in sketching the parallel and perpendicular lines using the

set squares. Display, explain and demonstrate towards learner-centred classroom to explore the lines, that is, differences and similarities on perpendicular and parallel lines.
<u>Participant 5</u> Used a chart to display and explain a line segment and its forms (Appendix I, Vignette 5).
<u>Participant 6</u> Used PowerPoint presentations and video to display and explain concepts of transformation through rotation.

Teachers incorporated visual aids in their initial plans, which is evident through self-made visual aids (Vignettes 2 and 5) and school provided material (Vignettes 1, 3, 4 and 6) for use in classrooms. Figure 4.2 highlights the teachers' skills of incorporating visual aids to engage learners and deliver the geometry content.

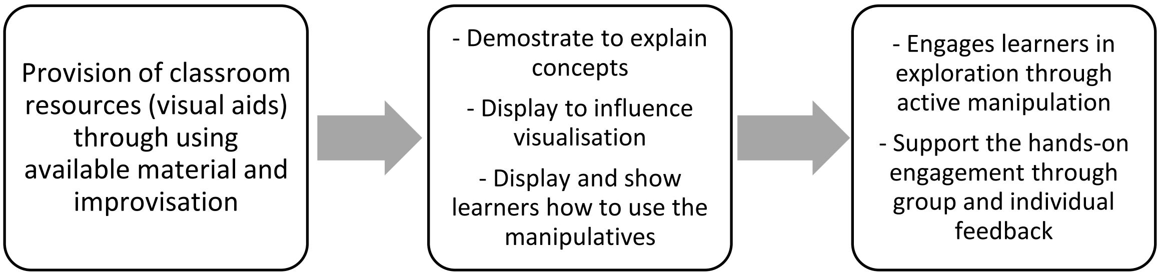

Figure 4.2

Teacher use of accessible and existing material

Their use led to teaching strategies that included displays, demonstrations and hands-on activities. These strategies supported exploration, allowed learners to work with materials and encouraged both group and individual learning.

4.3.2.1 Geometry facilitation process

In facilitating the semiotic representations, the participants used a range of visual aids as concrete objects, that is, charts, worksheets, manipulatives and software to introduce and explain geometry concepts. Demonstrations and illustration of diagrams influenced visual register where learners visualised geometric marks and symbols associated with diagrams. Visual register as prompted by teacher use of visual aids simplified the symbolic register as symbols were also identified in terms of their names (Appendix I, vignette 1.1, 2.1, 2,2 and 3.1). The teacher prompts learners to link visuals and symbols by labelling, naming and then progressing towards advanced to verbal registers. Geometry facilitation process through visual aids was seen to address transformation of representations in a process

i) prompting visual register through using visual aids to display, demonstrate, illustrate;
ii) Explaining further to link the visual connotations to symbolic meanings;
iii) the symbolic meanings are then translated to verbal implications.

Table 4.5 shows the geometric facilitation process in which Participants 1–6 conducted the semiotic representations lessons.

Table 4.5

Geometry Semiotic Registers Facilitation Process

Participants	Visual registers	Symbolic registers	Verbal registers
Participant 1 Vignette 1 Types of angles	• Chart with shapes of the three types of angles PowerPoint show of angles and their sizes in animation	• Symbols for right angle, straight angle and a revolution. • Writing the names of angles and their sizes • Shapes of angles and animation of adjustment of angle sizes	• Right angle is an angle of 90° • Straight angle is an angle of 180° • Revolution is an angle of 360°
Participant 2 Vignettes 2.1.and 2.2 2D and 3D objects	• Sketches of 2D net, • blocks of 3D objects	• Symbols/sketches of 2D shapes/nets • Blocks of 3D shapes	• 2D means two-dimensional; they are flat shapes figures with two dimensions of length and width. • 3D means three-dimensional shapes, that is, solid shapes that have three dimensions of length, width and depth
Participant 3 Vignette 3.1. types of angles Vignette 3.2. protractor to explore types of angles and their sizes	• displaying different types of angles. • Manipulatives protractor to construct angles	• Identification and measurement of angles using degree notation (For example, 90°) Marking angles with symbols	• Learners describe angles by name and size
Participant 4	• Worksheet diagrams showing parallel and perpendicular lines	• Use of symbols (‖ for parallel and ⊥ for perpendicular) • Drawing and labelling lines accordingly	• Explanation of relationships (for example Parallel lines never meet and perpendicular lines intersect at 90°)

Participants	Visual registers	Symbolic registers	Verbal registers
Vignette 4: Worksheet showing learners how to draw parallel and perpendicular lines			
Participant 5 Vignette 5: Chart showing the different types of straight lines	• Chart displaying types of straight lines	• Representation of lines through labelled diagrams and orientation	• describing the types of lines (For example, a horizontal line goes across)
Participant 6 Vignette 6: PowerPoint presentation rotation of shapes at 90◦ anticlockwise	• PowerPoint presentation showing rotation of shapes	• Use of rotation notation (For example, 90◦ anticlockwise) and positional changes of shapes	• Learners explain the transformation (For example, The shapes turn 90◦ to the left)

Visual aids support geometry learning by linking the three semiotic registers, namely, the visual, symbolic and verbal forms of representation. Visual forms, such as diagrams and images, help learners explore and understand concepts. This supports the development of symbolic understanding, such as using formulas and notation. Symbolic forms also work with language to describe shapes and solve problems. Interconnected semiotic registers help learners build deeper understanding. Learning is less effective when these registers are used separately, as understanding cannot be developed through only one type of representation.

4.3.3 Learner interaction through use of visual aids

Teachers' strategies such as demonstrating, displaying manipulatives and facilitating learner exploration are shown to activate specific characteristics and functions of visual aids that shape the learning experience and lead to observable affective and cognitive outcomes. Table 4.6 outlines learner interactions to respond to visual-aids-centred pedagogy to acquire learning skills and content.

Table 4.6

Learner Interaction and Response

Teacher	**Learner responses to teaching and their interaction**
<u>Participant 1</u> Facilitate active manipulation, exploration and visual comparison.	Learners responded through actively manipulating the cardboard and hinged stick models, discussing different angles and relating their manipulations to the animation they have visualised through the teacher's animated slide presentation of angles. Use of manipulable cardboard and hinged stick models as 3D figures prompted learning skills that include active manipulation, exploration and visual comparison.
<u>Participant 2</u> Facilitate cutting, folding and drawing Creativity	Learners explored the characteristics of 2D shapes through an activity of cutting, folding and drawing. Cutting papers to build 2D shapes, that is the square, folding the cut 2D shapes to build 3D figure which symbolised a cube and square pyramid, which the learners could unfold to draw and explore the sides of both the cube and square pyramid (Appendix I, Vignette 2). The learners explored the concept of building 3D objects to develop the spatial sense. That is, learner classroom engagement encompassed the activities on manipulation of actual objects or on-site demonstrations of the application of geometric principles, such as folding 2D nets for creating 3D models.

Teacher	Learner responses to teaching and their interaction
Participant 3 Facilitated discussions, usage of protractors to measure angle sizes	Influenced by the teachers' demonstration and explanations, learners engaged in discussions on differences and similarities among the types of angles and how to measure the magnitude of angles.
Participant 4 Facilitated through display and explanation Facilitated the usage of set squares to explore the lines	The availability of information on how to sketch parallel and perpendicular lines enabled learners to engage through manipulating the set squares to explore similarities and differences of the lines.
Participant 5 Facilitated through display and explanation	Differentiating between the different kinds of straight lines and new terminology presented (Appendix I, Vignette 5). Learners visualised to support comprehension and of symbols and related vocabulary.
Participant 6 Facilitated through display and integration of software through PowerPoint animations	The use of a PowerPoint presentation and animations captured learners' attention and fostered a positive and engaging classroom atmosphere, thereby enhancing interest and sustaining focus throughout the lesson. Development of conceptual understanding by supporting the transition from concrete to abstract learning through the visualisation of rotations and the application of these concepts during the activity whereby learners had to rotate different shapes on grid paper.

Learning skills through manipulation, exploration and co-operative work through discussions supported the learning experience. Figure 4.3 displays the development of the learning experience through the influence of the visual aids.

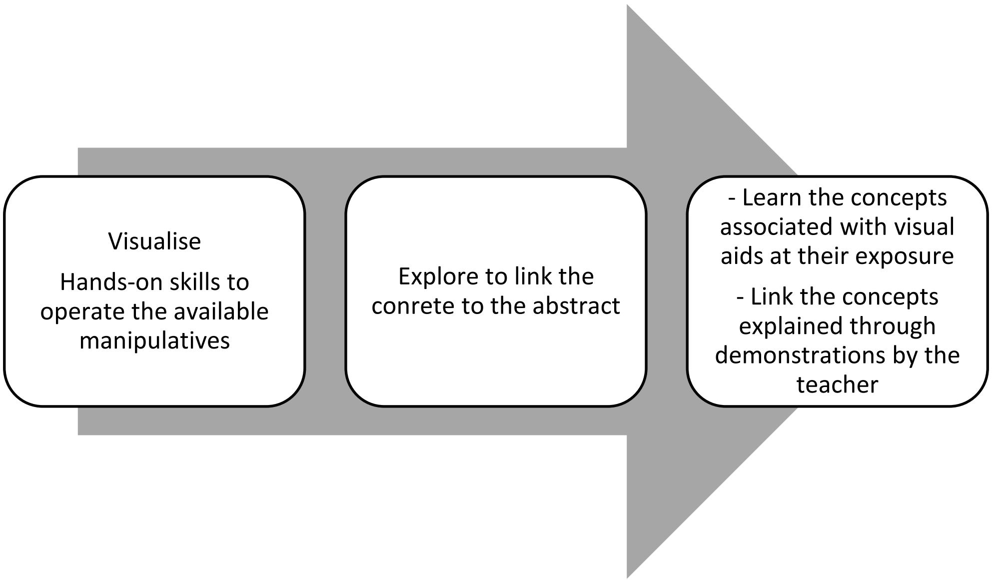

Figure 4.3

Learners' Learning Experience

4.3.4 Affective and cognitive effects towards the learning experience

Facilitation of geometry through integration of multiple visual aids supports learner interactions and play an essential role in shaping the learning experience through both the cognitive and affective effects. Learners' engagement in hands-on and visually mediated activities such as manipulation, folding, drawing and interaction with digital visualisation promoted active participation, curiosity and sustained interest, thus strengthening the affective domain. Learners were actively involved in exploring, discussing and comparing geometric concepts. This increased their motivation and helped to develop key skills such as spatial reasoning, conceptual understanding and procedural knowledge. Using different visual aids in teaching supports learners' interest and engagement which helps them develop knowledge and understanding.

4.3.5 Observation Summary

Teachers use visual aids to support geometry learning by using tools such as charts, instruments, and PowerPoint. They present diagrams, symbols, and shapes to help learners visualise and explore concepts. This process encourages hands-on interaction and supports both understanding and engagement. Figure 4.4 clearly shows the facilitation process towards development of the learning experience to support the cognitive effects, that is, comprehension of concepts and retention of knowledge.

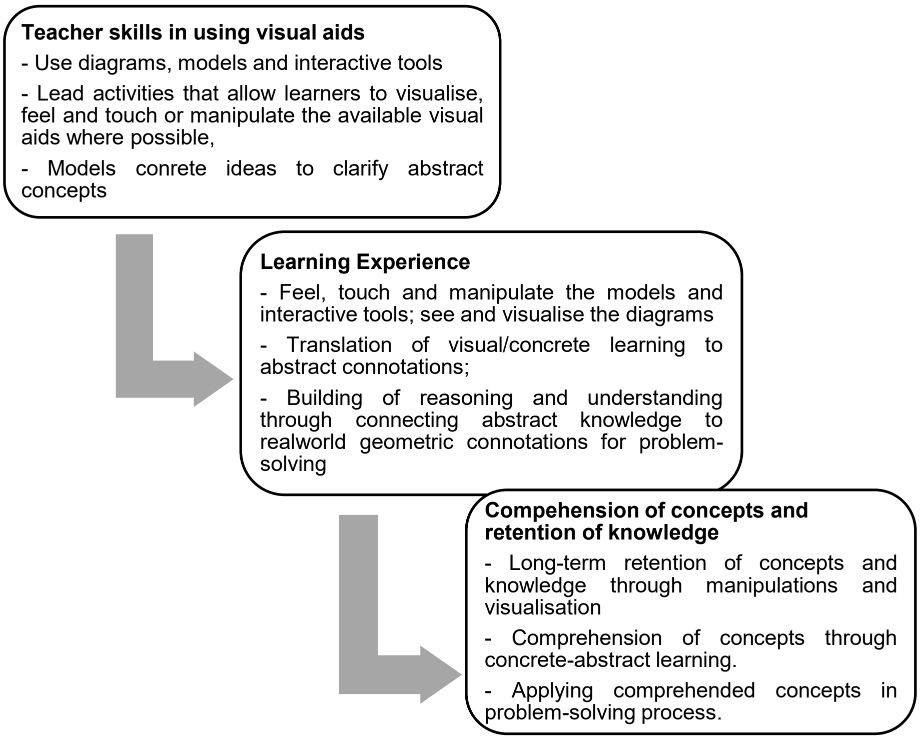

Figure 4.4

Semiotic facilitation approach

Providing learners with this learning experience shows a pattern where visual understanding develops first and then leads to deeper thinking, helping them understand geometry, apply geometric concepts and knowledge in problem-solving, therefore, commission to long term.

4.4 INTERVIEW FINDINGS

The interview findings are based on teacher responses to questions asked (Appendix H) to explore teachers' understanding, selection and application of visual aids in teaching geometry.

4.4.1 Teacher strategies through using visual aids

Teacher skills in using visual aids to teach geometry enhances the effectiveness in aligning the visual aids with the content to achieve the appropriate learning objectives. The interview focused on the teacher abilities to use teaching aids. and the following questions were asked;

(1) What are visual aids?
(2) Did you receive any formal training on how to use visual aids for teaching geometry?
(3) Explain how the training has influenced your ability to use visual aids appropriately in teaching geometry; and
(4) What criteria do you use to select the appropriate visual aids to meet learning objectives.

Teachers consistently used concrete objects such as diagrams, charts and pictures that appealed to learners' senses and encourage visual understanding and hands-on interaction (feel or touch). Furthermore, in their descriptions of visual aids, they highlighted the function of visual aids as prompting understanding and comprehension of concepts, for example, in Participant 3's detailed response that:

> *concrete objects that, when encountered at first hand, being able to feel it, touch it enable identification of objects, comprehension of concepts, recognition of relationships among figures and understanding of the topic taught*.

In response to a question on their professional development training, three participants claimed that they had learned how to use visual aids from the courses they completed at university and from professional development. Formal teacher training contributed to teachers' expertise in using teaching aids, for example, Participant 7 responded as follows:

> *Yes, in college we had a separate subject on teaching aids*.

Participant 5 response indicate that they were operating from experience, saying:

> *Networking really helps, that's how I've learned and trained myself*;

with Participant 6 having received no training. Professional development training is important, as participants said it improved their teaching, presentation skills and ability to engage learners.

On selecting the visual aids, teachers' ways of ensuring that appropriate teaching aids were selected. Relevance of visual aids was identified as one of the selection criteria, including alignment with the content and concepts taught, considering inclusion of all learners and their learning abilities; and selection criteria based on material that can enhance conceptual understanding.

4.4.2 Learner interaction through use of visual aids

Teacher skills and strategies to integrate appropriate visual aids in teaching geometry influence learners' learning experience towards development of geometric learning skills and knowledge. In understanding teachers' strategies of developing the learning experience through visual aids, the following question was asked: "In your experience, do you think the quality of the visual aids has an influence on the learning experience of the Grade 7 geometry learners? Explain your answer." Participants mentioned (1) enabling visualisation for enhanced understanding of geometric concepts; (2) remembering for better and sustained understanding; and (3) sustained concentration and interest (Table 4.6).

Table 4.7

Influence of Visual Aids on the Learning Experience

- *Most learners are visual learners and when the teacher uses visual aids, learners gain knowledge and a better understanding of concepts.*
- *Yes, it does help, t's easy for them to calculate angles. They can easily see and calculate the unknown angle.*
- *100%. If they see something, they remember it forever. It makes them comprehend better.*
- *Yes, I firmly believe it will, they can't understand it until they see it.*
- *I think it does, if it's of good quality, they'll be motivated. It helps keep them intrigued throughout the lesson.*
- *It does influence, in a positive way.*

All participants perceived visual aids as having a positive influence on learners' geometric learning experience.

4.4.3 Impact towards development of content knowledge

Using skills learned through visual aids helps improve understanding of geometry concepts. On the issue of geometric knowledge acquisition, the teachers were asked to describe the impact of using visual aids. Participants described the impact of visual aids as:

- *enabling effective teaching through effective conveyance of concepts and content to learners;*
- *supporting imagination though actual vision of objects and figures;*
- *visualising and retaining knowledge for long-term memory; and*
- *learner continuous engagement and stimulation of interest.*

4.4.4 Summary of interviews

Teacher interviews revealed that most of the teachers, that is, five teachers, had received some type of training in using visual aids to present the content and related concepts. Training and experience improved teachers' knowledge of visual aids including their impact on learning, and how to choose and use them effectively in teaching geometry (Figure 4.5).

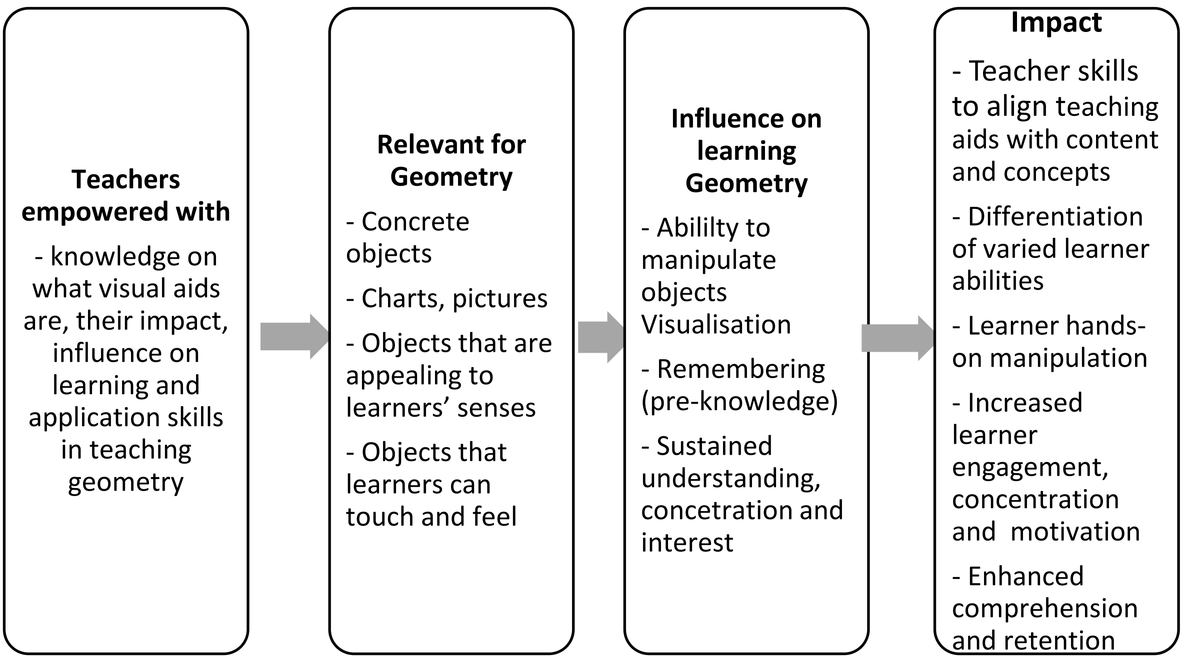

Figure 4.5

Interview summary on the use of visual aids

Teachers' responses suggest that they selected geometric visual aids based on relevance to content and concepts, and the influence of visual aids on learning the geometric concepts. Responses showed that the visual aids used in teaching geometry were simple, accessible materials such as charts, pictures, and diagrams, as well as concrete objects that learners could touch and explore. These experiences help learners handle objects, stay engaged, understand abstract ideas, build on what they knew and remember key concepts.

4.5 CHALLENGES OBSERVED IN GEOMETRY CLASSROOMS IN USE OF VISUAL AIDS

Considering the types of visual aids used by all participants, teachers relied on improvisation when resources were not provisioned by the school or department of education. Participants 2 and 5 improvised and created charts, that is, hand-drawn materials; while Participants 1, 3, 4 and 6 used available material (Cf. Appendix I). In addition, observable disparities in the availability and quality of visual aids across schools influenced lesson delivery and learner participation. For example, in most instances, learners in these contexts required repeated explanation and struggled to connect concepts due to limited visual reinforcement. Challenges such as limited access to resources in under-resourced schools, therefore, hindered the effective use of these tools which perpetuates educational disparities.

4.6 TRIANGULATION OF DATA

Findings from observations and interviews show that visual aids support Grade 7 learners to understand abstract geometry by aligning with lesson goals, improving engagement, and supporting comprehension and motivation. The participants also pointed out that visual aids help learners visualise and concretise geometric concepts which helps them to bridge the gap between abstract ideas and tangible understanding. As such, well-aligned visual aids enhance learners' ability to differentiate shapes and comprehend relationships between angles and figures, which are critical for mastery in geometry. On the other hand, this study also pointed out the importance of differentiation when using visual aids as they should be tailored to varying learner abilities to ensure inclusivity. This was reported to help weaker learners while challenging advanced ones.

Furthermore, this study revealed that hands-on activities using visual aids helped to make learning interactive and memorable. This was also reported to help in the promotion of active engagement and long-term retention within the classroom. These findings highlight the potential of visual aids to transform Grade 7 geometry instruction and demonstrates their critical role in enhancing learning outcomes, notably in diverse and resource-constrained educational contexts. T

Table 4.7 links the findings from both observation and interviews showing critical implications for teachers' skills in using visual aids to teach geometry for the improvement of the learners' geometric learning experience.

Table 4.8

Triangulated Observation, Interview Findings and their Implications

Observation findings	Interview findings	Implications	Theme
Visual aids aligned with lesson objectives improved clarity and understanding; misaligned aids caused confusion.	Teachers emphasised the importance of choosing relevant aids that accurately reflect curriculum goals and avoid learner misconceptions.	Alignment between visual aids and content is essential to promote clarity, accuracy and relevance in instruction.	Alignment with teaching content and learning objectives
Visual aids were adapted to different learner levels; concrete aids supported weaker learners while complex tasks challenged advanced ones.	Teachers confirmed the need to tailor visual aids to accommodate diverse learner abilities and ensure inclusive participation.	Differentiated visual instruction enables all learners to engage meaningfully, improving equity and learner outcomes.	Differentiation for varied learner abilities
Manipulation of shapes enhanced understanding of geometric properties like edges and vertices; learners engaged in practical problem-solving.	Teachers stated that concrete experiences help bridge gaps in abstract thinking, especially for weaker learners with limited exposure to learning tools.	Hands-on learning supports deeper understanding and promotes inclusivity through practical exploration of geometric relationships.	Hands-on learning and interactive experience
Learners were visibly more engaged when colourful or real-world visual aids were used; disengaged learners became active participants.	Teachers reported heightened learner interest and emotional engagement, contributing to sustained attention and a positive learning atmosphere.	High-quality visual aids foster cognitive and emotional engagement, critical in classrooms with diverse and often disinterested learners.	Increased engagement and motivation

Observation findings	Interview findings	Implications	Theme
Learners better retained and understood geometric concepts when engaging with visual aids such as 3D models and diagrams.	Teachers affirmed that visual learners benefit from concrete representations, which clarify relationships between geometric figures.	Visual aids support conceptual understanding and long-term retention, particularly when used to represent abstract concepts in tangible ways.	Enhanced comprehension and retention

4.6.1 Visual aids teaching towards the learning experience

The conceptual model presented in Figure 4.6 gives an overview of how visual aids support teaching to influence the learning of geometry.

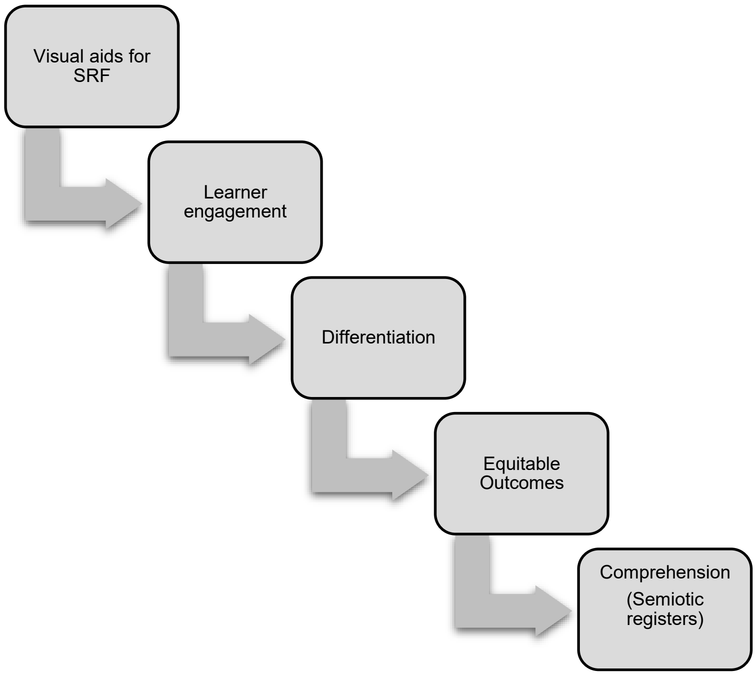

Figure 4.6

Conceptual Model on utilisation of Visual Aids

The model situates visual aids as a mediating system between education intentionality and learning outcomes. Visual aids are semiotic instruments that enable transitions between symbolic, iconic and indexical representations of geometric knowledge. This means that 2D diagrams, 3D models, and multimedia are not just extra aids. They are semiotic tools that help learners move from concrete understanding to abstract symbols. The first dimension of the model reflects the motivational function of visual aids. In the process of working with iconic representations, such as diagrams, graphs and models, learners create indexical connections to real-world contexts and turn abstract geometry into meaningful experiences. Indexical representations contextualise mathematical meaning within experience and subsequently increase cognitive investment. Visual aids raise curiosity and interest and through active participation, they promote affective engagement which results in heightened attention and interest in learning.

The second pathway is that of differentiation and equity, where visual aids allow for instruction to cater to diversified levels of cognition and learning needs. Different representations support different cognitive processes. Practice brings out that simpler, concrete visual aids facilitate learners who rely on tangible scaffolds, whereas more abstract or dynamic visuals spur high-order thinking in advanced learners. Such differentiation practice enables equitable participation to be realised as all learners, irrespective of ability, access and ultimately every learner process geometric knowledge through coherent semiotic systems. In this respect, the model shows how visual aids enable inclusion in learning geometry through multiple pathways of representation.

The model's third pathway stresses comprehension through engagement. As learners manipulate and interpret visual material, they cross semiotic systems by relating symbolic formulae to visual pattern and verbal explanation. Therefore, semiotic coordination is evident wherein comprehension ensues from the integration of multiple representational systems. The SRF process denoted in Table 4.5 confirm that learners who engaged visual aids, they developed more thorough conceptual understanding of properties of shapes, angle relations and spatial organisation. In such multilevel engagement, learners not only visualised geometric relationships but internalised them through cognitive translation across semiotic modes.

4.7 CHAPTER SUMMARY

Chapter 4 highlights the positive impact of visual aids like 2D and 3D models on learners' understanding and memory of geometric ideas, underlining the value of interactive learning and hands-on experiences. In addition this chapter outlined the process of semiotic representation facilitation approach through visual aids as:

i) alignment with teaching content and learning objectives;
ii) increased engagement and motivation;
iii) differentiation for varied learner abilities
iv) hands-on learning and interactive experience and
v) enhanced comprehension and retention.

This process emphasises the importance of tailoring instruction to suit various learner capabilities using visual aids, emphasising the importance of aligning visual aids with teaching content and learning goals for optimal educational outcomes. Furthermore, Chapter 4 highlights that the importance of visual aids in helping learners better understand abstract geometry concepts, especially in schools with limited resources.

CHAPTER 5

INTERPRETATION OF DATA, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This chapter focuses on the interpretation of data, conclusions and recommendations based on the use of visual aids in teaching Grade 7 geometry to enhance the learning experience. In addition, the research questions are answered, objectives are evaluated, study implications, conclusion and recommendation are presented.

5.2 THE USE OF VISUAL AIDS IN TEACHING GEOMETRY TO ENHANCE THE LEARNING EXPERIENCE

The main question of this study asks, how does the use of visual aids in teaching grade 7 geometry enhance the learning experience. The study's classroom and interview evidence demonstrates that visual aids substantively improved Grade 7 learners' comprehension, engagement and retention in geometry, thereby empirically buttressing the claims advanced in the literature (Alex & Mammen, 2018; Bansilal & Ubah, 2019; Mabena et al., 2021). Across observed lessons, teachers integrated charts/posters, manipulatives (protractors, set squares and hinged stick models), paper-based 2D nets and folded 3D forms, as well as multimedia presentations and PowerPoint animation (Table 4.3). In Participant 1's class on angles, the combined use of a wall chart, hinged stick models and an animated slide sequence elicited sustained manipulation, comparison and explanation by learners. The activity yielded a maximum participation, with learners confidently classifying and measuring angles and articulating reasoning in peer talk (Appendix I, Vignette 1.3). Similar gains in conceptual clarity were observed when learners constructed and folded nets into cubes and square pyramids under Participant 2. In this regard, direct handling of edges, faces and vertices consolidated the 2D–3D relationship and supported accurate geometric vocabulary use during follow-up tasks (Appendix I, Vignette 2). These concrete–representational experiences mirror evidence that well-selected visuals bridge abstraction and practice which fostered spatial reasoning towards problem-solving (Bansilal & Ubah, 2019; Rowland & Ruthven, 2011).

Learner engagement and motivation rose visibly with the introduction of visual stimuli. In multiple lessons, previously passive learners-initiated questions and participated in group discussions once charts, worksheets or multimedia were introduced (Participants 1, 3 and 4; Appendix I, Vignettes 1, 3 and 4). Observation notes recorded heightened attentiveness during the rotation lesson that combined PowerPoint animations (Participant 6), followed by accurate ruler-based enactment of rotations at specified angles. Triangulation confirms this pattern, teachers reported immediate attentional gains and deeper participation when visual aids were used, describing on-task persistence and learner-centred processes (Table 4.7). These affective shifts align with claims that thoughtfully designed visuals elicit curiosity and sustain motivation, which in turn mediate cognitive uptake (Mabena et al., 2021).

Hands-on and interactive experiences functioned as the principal mechanism through which visual aids translated into learning. Learners' manipulation of hinged models, use of protractors and set squares and construction of paper-based nets produced fewer clarification requests, more precise sketches and more accurate angle readings (Participants 1, Participant 3, Participant 4; Table 4.3). Interview testimony converged on the view that "seeing and touching" converts initially unclear ideas into tractable tasks, particularly for learners who struggle with purely verbal exposition. This is consistent with research emphasising that multimodal representation such as diagrams, models and animations, enriches cognitive processing and strengthens long-term retention (Alex & Mammen, 2018; Rowland & Ruthven, 2011).

However, the effect of visual aids proved contingent on access, quality and alignment to curricular intent. Resource-rich classrooms employed printed charts, geometry kits and projection which enabled accurate depictions and discovery-oriented activity, in which learners actively explored and constructed geometric knowledge through inquiry (Meirbekov & Salikhanova, 2021). By contrast, under-resourced settings relied on devised sketches and cardboard models that constrained precision and reduced opportunities for manipulation (for example, participant 5 in Table 4.3 and vignette 5). Teachers repeatedly linked such constraints to superficial learning and the need for repeated re-explanation, a structural pattern the literature associates with uneven implementation capacity (Chikiwa & Ludwig, 2023). When visual materials did not match the lesson, learners became distracted and completed tasks only partially. When visuals were well aligned, such as using protractors with angle charts, learners showed accurate understanding and application (Participants 1, Participant 2, Participant 3; Table 4.3). This is consistent with studies by John Hattie (2023), which highlight that well-aligned instructional resources enhance learners' understanding, and by Richard E. Mayer (2021), who found that relevant visual representations facilitate meaningful learning and improve knowledge application. These findings reinforce guidance that educator training should emphasise purposeful selection and alignment of representations to outcomes (Smith & Cekiso, 2020).

Furthermore, the findings imply that visual aids supported differentiation and inclusion in mixed-ability classes. Concrete manipulatives and stepwise tasks scaffolded foundational understanding for weaker learners (e.g. folding nets into solids in Participant 2’s lesson), while multimedia simulations and open-ended measurements extended reasoning for more advanced learners (Participant 6). Observation records indicated simultaneous and meaningful engagement across ability levels and reduced anxiety when dealing with abstract content. Thus, illustrating parallel affective gains (confidence, persistence) and cognitive gains in moving from concrete to abstract and in spatial reasoning development (Table 4.3, Table 4.4, Table 4.5, Table 4.6 and Table 4.7). Overall, the evidence shows that when visual aids are accessible, well chosen, and aligned with curriculum goals, they improve learners’ geometry learning by making concepts clearer, increasing engagement, and strengthening understanding (Alex & Mammen, 2018; Bansilal & Ubah, 2019; Chikiwa & Ludwig, 2023; Rowland & Ruthven, 2011; Smith & Cekiso, 2020).

5.3 RESPONDING TO THE RESEARCH SUB-QUESTIONS

The following research sub-questions are responded to: (1) What teaching skills are relevant towards using visual aids to enhance Grade 7 learners’ geometric learning experience? (2) How can the use of visual aids in teaching influence Grade 7 learners’ geometric learning experience? (3) What geometric learning skills and knowledge are developed using visual aids?

5.3.1 What teaching skills are relevant towards using visual aids to enhance Grade 7 learners’ geometric learning experience?

The triangulated findings from classroom observations, teacher interviews and the literature review identify a set of core pedagogical competencies that determine how effectively visual aids are used to enhance Grade 7 learners’ geometric learning experience. The first essential skill is the intentional selection and alignment of visual aids with specific curricular objectives. As indicated in Table 4.7 under the theme "Alignment with teaching content and learning objectives," the data show that when visual aids corresponded directly with the lesson goal, learners demonstrated higher comprehension and task accuracy. For example, illustrations of angle types or 2D-3D relationships enhanced conceptual clarity among learners in Participant 1 and Participant 2's classrooms, as detailed in Appendix I, Vignettes 1 and 2. These reflect that conscious structured alignment of content and visuals promotes clear comprehension and long-term retention (Duval, 2003; Zulkifli et al., 2022).

Competency in manipulative and representational pedagogies is also needed and allows the teacher to connect concrete and abstract forms of knowledge. Data from Table 4.3 and Figure 4.1 indicated that the use of 2D diagrams, 3D models and mathematical instruments such as protractors and set squares supported learners' spatial reasoning and understanding of geometric properties. This supports Duval's theory of semiotic representation, which suggests that to develop geometric knowledge, learners must process symbolic, visual and verbal representations (Duval, 1995, 2003, 2017). The effective integration of these representational systems by the teacher means that learners derive meaning from concrete to abstract geometric relationships through practical work.

A third skill represented in the data relates to differentiation and adaptability within instruction. As shown in Table 4.7 under "Differentiation for varied learner abilities", increased inclusivity came from those teachers who differentiated the level of complexity of visual aids according to learner abilities. For example, Participant 5 used simplified paper models for weaker learners and analytical tasks for advanced learners, where the variation is supported by Glynn (2022) and Noon (2024). The observation data verify that active participation of learners from all levels of ability was indeed possible due to the use of both concrete and abstract visual aids during differentiated instruction and thus had equal access to conceptual learning.

Another important teaching competence is to encourage learner interaction and engagement through hands-on activities. From observation data presented in Table 4.5 and illustrated in Figure 4.1, it can be learned that learners who manipulated models, drew geometric figures and made use of instruments were more engaged and displayed richer conceptual insights than their peers. This was particularly evident in classes where the teachers were able to engage the learners in exploratory work and not purely a lecture. The results are consistent with Dlamini and Nkambule (2020) and Moyer-Packenham et al. (2019), who observe that interactive learning enhances spatial reasoning, motivation and problem-solving processes.

Furthermore, data suggest that reflective and adaptive professional practice underlines effective use of visual aids. Teachers with mid and higher levels of experience having formal qualifications (specifically participants 1,2 and 3) were found to be much more confident in using visual tools and adapting instruction dynamically to responses from the learners, as seen from Table 4.5. This was reflected in Smith and Cekiso's (2020) and Sternberg's (2023) arguments that continuous professional development strengthens one's pedagogical adaptability and develops one's reflective capacity. The empirical data also show coherence between visual aids and instructional goals among participants with extended teaching experience, such as Participants 1 and 3, translating into better learner outcomes.

Nonetheless, evidence from Table 4.3, Table 4.5, Table 4.6, Figure 4.1 and Figure 4.3 has supported the most relevant teaching skills concerning effective use of visual aids. This includes strategic selection and curricular alignment of visual materials, mastery of representational and manipulative pedagogy, differentiation across ability levels, facilitation of hands-on engagement and reflective professional practice. These interconnected competencies ensure that the visual aids are integrated pedagogical tools that support deeper understanding, increased participation and greater inclusivity when learning Grade 7 geometry.

5.3.2 How can the use of visual aids in teaching influence Grade 7 learners' geometric learning experience?

The triangulated data from classroom observations, teacher interviews and supporting literature demonstrates that the use of visual aids notably shaped Grade 7 learners' development of geometric learning skills and knowledge by enhancing comprehension, spatial reasoning, engagement and inclusivity.

As indicated in Table 4.2 and Table 4.3, learners who engaged with 2D diagrams, 3D models and multimedia tools demonstrated strengthened spatial visualisation and reasoning. Interaction with manipulatives and folded nets enabled accurate identification of vertices, edges and faces which reflected learners' ability to analyse spatial relationships. This pattern aligns with Duval's theory of semiotic representation, which emphasises the cognitive benefits of transitioning between representational forms (Duval, 1995, 2003, 2017). The data show that combining charts, hinged models and digital slides provided multiple entry points for understanding and facilitated the development of spatial awareness grounded in tangible geometric experience.

Table 4.7 further illustrates strengthened conceptual clarity when visual aids were aligned with curricular content. In relation to the outcome, *enhanced comprehension and retention*, learners displayed improved accuracy during follow-up tasks when teachers used text, sketches and manipulatives simultaneously. These findings reflect the observation that multimodal instruction supported retention and conceptual discrimination of geometric properties such as angle types and relationships between 2D and 3D figures. This outcome indicates that visual comparison and hands-on manipulation enhance understanding and memory of geometric concepts (Dlamini & Nkambule, 2020; Zulkifli et al., 2022).

The development of problem-solving and reasoning skills emerged clearly in Theme 3 of Table 4.7 and Figure 4.1. Learners who constructed models or used instruments such as protractors and set squares demonstrated more independent problem-solving and higher task accuracy. The instructional sequences observed, which combined visual demonstration, manipulation and guided application, supported the view that visual tools enable hypothesis testing and logical inference, a finding consistent with Smith and Cekiso (2020). These processes provided a scaffold for learners to connect procedural actions to conceptual understanding.

Visual aids also supported metacognitive development. Figure 4.1 Observation notes highlight that during group tasks, learners verbalised their reasoning and monitored progress, self-correcting accordingly. These reflect deepening metacognitive awareness and strategy use to reinforce the argument of Sternberg (2023) that such visual engagement acts to promote reflective learning and self-regulation within mathematical contexts.

Furthermore, the use of visual aids enhanced inclusive and differentiated teaching practice. In Themes 4 and 5 of Table 4.7, teachers indicated that they adapted resources for different learning contexts and levels of ability. Learners in relatively well-resourced settings made use of multimedia presentations and structured geometry kits. In under-resourced settings, teachers supported access through improvisations, such as hand-drawn diagrams and paper models. These practices supported learners with various levels of readiness in meaningfully engaging in the geometry tasks. The findings support the literature of Glynn (2022) and Noon (2024), who assert that visual scaffolds reduce the cognitive load and promote equitable participation during mathematics learning.

Considering the discussion above, it should be noted evidence from Tables 4.2 through 4.7, Figures 4.1 and 4.6 and the coded observation vignettes illustrates that visual aids were central in developing learners' geometric understanding. They enhance comprehension by means of multimodal representation, develop spatial and reasoning skills by means of manipulation and practical engagement, and further equitable participation in diverse classroom contexts. Considered against the backdrop of theoretical and empirical literature, these findings establish visual aids as a foundational pedagogical tool that makes geometry instruction an accessible and cognitively rich and inclusive learning experience for Grade 7 learners.

5.3.3 What geometric learning skills and knowledge are developed through visual aids?

The triangulated findings from classroom observations, teacher interviews and the literature review collectively demonstrate that visual aids promote the development of both foundational and higher-order geometric skills among Grade 7 learners. The first key competency developed through visual-aid-based learning is spatial visualisation and geometric reasoning. As reflected in Table 4.7 and Figure 4.1, learners who engaged with 2D diagrams, 3D paper models and hinged stick manipulatives were able to identify and describe vertices, edges, faces and angles accurately. These activities strengthened learners' ability to mentally rotate and compare geometric forms. This aligned with Duval's theory of semiotic representation, which emphasises that geometric understanding emerges from coordinating visual, verbal and symbolic registers (Duval, 1995, 2003, 2017).

The findings show that learners developed visual discrimination and spatial perception when manipulating geometric models, as observed in Participant 1's and Participant 2's classrooms (Appendix I, Vignettes 1 and 2). This was further supported by the triangulated evidence in Table 4.7 on the outcome *enhanced comprehension and retention*, where learners demonstrated improved recall of geometric structures following visual and hands-on instruction.

Secondly, the data highlight that learners acquired deeper understanding of geometric properties and relationships through practical engagement with visual representations. Observation data in Table 4.5 show that the use of visual aids such as models of prisms, pyramids and polygons enabled learners to internalise rules related to angle sums, shape classification, congruence and symmetry. These experiences translated theoretical principles into measurable outcomes, as learners demonstrated improved performance in tasks requiring the application of geometric rules. The findings correspond with the literature, that is, Zulkifli et al. (2022), Dlamini and Nkambule (2020), identifies visual interaction as a way to reinforce conceptual understanding. Measurement and estimation skills were also strengthened through tools like protractors, rulers and nets, which is shown in Table 4.4. Learners who used these manipulatives displayed higher accuracy and confidence in measuring and constructing geometric figures. This confirmed Moyer-Packenham et al.'s (2019) assertion that experiential learning through manipulatives enhances procedural fluency and conceptual depth.

A third significant competence is that of problem-solving and deductive reasoning. This is captured in Table 4.7 on the theme *hands-on learning and interactive experience* and in Figure 4.3. Moreover, this information presented in Figure 4.3 highlighted that the learners who experienced creating or manipulating models in geometry were better equipped to learn from the concrete to the abstract in development of conceptual understanding. These results further signify how visual tools support the testing of hypotheses, logical proof and development of reasoning. Data confirm the literature from Glynn (2022) and Sternberg (2023) that visual tool scaffolds support learners in developing generalisations, testing their conjecture and hence building their analytical and deductive competence.

Another observed learning outcome is representational fluency, the capability to move flexibly between the visual, the verbal and the symbolic modes of geometric representation. Evidence from Table 4.7 on the theme *differentiation for varied learner abilities*, indicates that when learners were exposed to multiple forms of visual representation in diagrammatic, algebraic notations and physical models, they demonstrated heightened understanding and adaptability. Teachers combined multiple approaches of representation in such a way that learners' cognitive flexibility was accommodated by allowing them to relate the visual imagery to the formal mathematics expressions. In this regard, Duval (2017) argues that representational fluency is an important basis for achieving conceptual coherence in geometry learning.

In addition, it was shown that the learning interventions supported with visual aids also contributed to enhanced learner confidence and metacognitive awareness. For example, observation notes in Figure 4.1 reveal verbalisation of reasoning processes, monitoring of accuracy and self-correction of errors while executing group tasks, while the theme *increased engagement and motivation* in Table 4.7, reflects positive affective responses and growing confidence. These data sets indicate that through the use of visual aids, learners were able to envision their steps of reasoning and reflect upon considerations of their progress, thus reinforcing reflective learning and persistence in completing complex tasks. This goes in tandem with a similar view by Sternberg (2023) that visual learning is associated with enhanced self-regulation and metacognitive control.

In the context of the foregoing discussion, evidence from Tables 4.1, Table 4.2, Table 4.3, Table 4.4, Table 4.5, Table 4.6, Table 4.7, Figures 4.1 to Figure 4.6 show that the use of visual learning aids develops the key geometric learning skills, including spatial visualisation, reasoning, understanding geometric properties, measurement, problem-solving, representational fluency and metacognitive awareness. Merging visual, tactual and symbolic learning modes, visual learning aids turn geometry from an abstract discipline into an experiential and cognitively engaging field of study, helping Grade 7 learners apply geometric understanding confidently and with conceptual depth.

5.4 Evaluating the research objectives

The research objectives achieved by this study are:

- to explore the teaching skills relevant towards using visual aids to enhance Grade 7 learners' geometric learning experiences.
- to determine how the use of visual aids in teaching influence Grade 7 learners'

geometric learning experience.

- to identify the geometric learning skills and knowledge that are developed through the use of visual aids.

5.4.1 To explore the teaching skills relevant towards using visual aids to enhance the learners' geometric learning experiences.

This study shows that teachers employ a range of critical pedagogical skills in the effective use of visual aids, which are consistent with the literature on geometry instruction. These include the ability to select visual aids that are relevant and aligned to specific geometric concepts, differentiate instruction to accommodate diverse learner abilities, and ensure coherence between instructional content and visual representation. For instance, participants emphasised that visual aids *must be relevant to the topic* (Participant 1) and must be chosen *according to the concept that you're teaching* (Participant 3), emphasising strong alignment between instructional tools and content. Teachers also demonstrated an awareness of learner diversity, with Participant 5 noting the need to "cater for all" learners and Participant 4 emphasising that visual aids should particularly support "weaker learners." This demonstrates the principle of differentiated instruction, where teaching strategies are adapted to meet varied cognitive needs. The findings also illustrate that teachers facilitate the transition from concrete to abstract understanding using visual aids, as learners can *see, touch, [and] feel* geometric concepts (Participant 3), thereby enhancing comprehension. This coincides with constructivist perspectives and Duval's theory of semiotic representation, which emphasise the importance of multiple representations in bridging abstract and concrete knowledge. Also, literature in Chapter 2 asserts that visual aids are most effective when teachers possess strong pedagogical content knowledge and the ability to scaffold learning experiences appropriately (Ball, 2020; Smith & Cekiso, 2020; Žakelj & Klancar, 2022). Therefore, the study confirms that the effectiveness of visual aids is not inherent in the tools themselves but is largely dependent on teachers' pedagogical competence in selecting, aligning and implementing these resources to support meaningful geometric learning.

5.4.2 To determine how the use of visual aids in teaching influence Grade 7 learners' geometric learning experience.

This study further demonstrates that the use of visual aids notably influences Grade 7 learners' learning experiences by enhancing both cognitive and affective dimensions of learning, which is supported by Chundung et al. (2020) and Idris et al. (2020). Chundung et al. (2020) states that visual aids "improve learners' focus, motivation and excitement" while Idris et al. (2018) states that visual aids "increase understanding and memory because they give more real-world examples to examine", emphasising their role in deepening conceptual engagement. This is evident in the findings (Table 4.6.), where participants indicated that learners "can't understand it until they see it" and that "if they see something, they remember it forever," demonstrating how visual aids support comprehension and long-term retention. Similarly Žakelj & Klancar (2022), the emphasises that visual aids enable learners to move "from concrete to pictorial and then to symbolic representations", thereby facilitating the transition from abstract to meaningful understanding. This is reflected in the classroom context, where learners were able to more easily "calculate angles" and grasp geometric relationships when visual aids were used. From an affective perspective, literature further suggests that visual aids create "a more engaging learning environment" that improves learner motivation and interest (Vavra et al., 2011), which aligns with participants' observations shown in Table 4.6. that learners remained "intrigued throughout the lesson" and showed sustained concentration when visual aids were incorporated. These findings also resonate with Duval's theory of semiotic representation, which emphasises that learning is strengthened through interaction with multiple representations that connect abstract concepts to concrete experiences. Hence, the study confirms that the use of visual aids transforms the learning experience by simultaneously enhancing learners' cognitive understanding and affective engagement, ultimately leading to more meaningful and effective geometry learning.

5.4.3 To identify the geometric learning skills and knowledge that are developed through the use of visual aids.

The use of visual aids in teaching geometry notably and in multiple ways influences the learning process of Grade 7 learners. The triangulated results drawn from classroom observations, teacher interviews and the reviewed literature collectively confirm that visual aids play an essential role in improving learners' comprehension, retention, interest and spatial reasoning. As shown in Table 4.7, Figures 4.1 and Figure 4.3, visual aids helped learners visualise abstract geometric concepts through tangible and interactive representations. Learners who engaged with charts, manipulatives, 2D sketches and 3D models demonstrated enhanced understanding of shape properties, spatial relationships and measurement. This is consistent with the theoretical propositions of Duval (2003) and empirical findings by Dlamini and Nkambule (2020).

The study found that effective alignment of visual aids with curriculum objectives contributed to better conceptualisation of geometric principles. That is, when teachers purposefully selected and integrated visual aids corresponding to specific lesson outcomes, learners showed improved visual abilities, deductive thinking and representational competence. In relation to geometric knowledge acquired, well-structured visual learning environments enhance reasoning and representational fluency in geometry (Glynn, 2022; Zulkifli et al., 2022). Therefore, learners exposed to visual aids, for example 2D diagrams and 3D materials, were better at identifying angles, constructing geometric figures and interpreting spatial relations.

Moreover, the study reinforces that visual aids increase learner motivation and engagement. As indicated in Table 4.7 in relation to the theme i*ncreased engagement and motivation* learners displayed heightened attentiveness and participation when teachers introduced visual materials that were colourful, contextually relevant and interactive. Observational data (Figure 4.1) show that visual-rich lessons sustained learner concentration and encouraged participation among previously passive learners. These findings are consistent with Moyer-Packenham et al. (2019), who assert that visual materials promote emotional investment in mathematics learning and align with Paivio's (1990) dual coding theory, which posits that the integration of verbal and visual inputs enhances memory and comprehension.

Results also reveal the use of visual aids in differentiated instruction. Considering teacher practices of *differentiation for varied learner abilities*, as represented in Table 4.7, it is evident that modified visual materials suit the varied levels of ability and readiness that learners possessed. These are made from the range of resources used, such as hand-drawn figures, physical models and multimedia presentations, that cater to the needs of struggling and able learners. In so doing, inclusivity has been attained and equal learning outcomes ensured-an aspect supported by Noon (2024) to be achieved through differentiation for the purposes of cognitive inclusion. Further evidence from the observations identified that the assured use of visual aids in differentiated instruction was instrumental in ensuring that learners were full of confidence and actively participated in activities, which eventually promoted an inclusive classroom environment.

However, such findings also speak to issues of inequality in the distribution of resources within educational settings. This is reflected in Table 4.3 and further discussed as part of “Challenges of access and resource availability” in Table 4.7. These schools often used improvised, low-quality visual aids, which reduced the possibility of effective learner participation and conceptual insight. This was especially true for classrooms without access to multimedia or geometric kits, which ultimately limited the active/experiential potential of the learning. These inequalities reflect the concerns of Smith and Cekiso (2020), who argue that a root cause of the continued inequity in South African education has been unequal distributions of teaching materials.

It therefore follows from Tables 4.2, Table 4.3, Table 4.4, Table 4.5, Table 4.6, Table 4.7, Figure 4.1 and Figure 4.3 that the use of visual aids makes abstract geometry concepts accessible, supports the development of geometric skills and fosters learner engagement and inclusivity. This overall effect is modified by the quality of implementation, teacher competence and equity in resource allocation. Used purposefully and inclusively, visual aids make the teaching of geometry a learner-centred, engaging and cognitively enriching experience, hence promoting both conceptual understanding and educational equity in diverse South African classrooms.

The collective findings of this study affirm that the integration of visual aids into Grade 7 geometry instruction notably enhances the quality of the learning experience by promoting cognitive, conceptual and affective engagement among learners. Across all three sub-questions, data from observations, interviews, and literature show that visual aids are essential teaching tools that make abstract geometry clear and meaningful.

This study found that effective use of visual aids requires skills such as aligning them with curriculum goals, using multiple representations, adapting materials for learners, and promoting active participation. These skills enable educators to design learning experiences that are inclusive, conceptually rich and tailored to the cognitive levels of diverse learners (Noon, 2024; Zulkifli et al., 2022). Moreover, the use of visual aids was shown to positively influence the development of key geometric learning skills, including spatial visualisation, problem-solving, deductive reasoning and conceptual understanding of shape properties, measurement and symmetry. Learners not only improved in their ability to visualise and manipulate geometric forms but also developed greater metacognitive awareness and confidence in their mathematical abilities (Moyer-Packenham et al., 2019; Sternberg, 2023).

The findings further show that visual aids contribute directly to learner equity by supporting differentiated instruction and compensating for disparities in background knowledge, especially in under-resourced contexts. Appropriately selected and used skilfully, visual aids enable high-performing and underperforming learners to participate effectively in learning processes, thus encouraging inclusive education and reducing achievement disparities (Glynn, 2022; Smith & Cekiso, 2020). In brief, the study shows that visual aids improve Grade 7 learners' understanding, increase engagement, support differentiated teaching, and promote fair access to learning in geometry. Such outcomes have particularly powerful policy and practice implications in multiculturally composed and resource-strained educational contexts, where explicit use of pictorial materials is a stimulus towards learner empowerment and improved mathematics outcomes.

5.4 IMPLICATIONS OF THE STUDY ON THE TEACHING OF GEOMETRY

5.4.1 Theoretical implications

These findings substantively support and extend Duval's theory of semiotic representation, showing exactly how learners' geometrical understanding is developed through the connected use of symbolic, iconic and indexical representations (Duval; 1995; 2003; 2017). Observations in the classroom and interviews with teachers revealed that 2D cut-outs, 3D models, charts and contextual objects are vital semiotic mediators that link abstract symbolic ideas to concrete experience. For instance, Participant 2's use of cut-outs and nets allowed learners to switch between iconic (diagrammatic) and symbolic (notational) systems in identifying the properties of shapes and constructing 3D forms; such a facility instantiates Duval's principle of representation conversion. Again, Participant 6's lesson incorporated indexical representations through real-world visuals that situate abstract geometrical concepts in already familiar contexts and hence reinforce the cognitive bridge between visualisation and conceptual reasoning. Instances where teachers combined multiple modes of representation corresponded with heightened learner engagement, spatial reasoning and representational fluency and confirmed Duval's assertion that deep understanding depends precisely on moving flexibly among semiotic systems. Conversely, in classrooms relying on single forms of representation, such as Participant 7's poster-based lesson, learning outcomes were relatively limited, illustrating the theoretical risk of semiotic rigidity. Overall, the study extends Duval's framework by showing that the intentional alignment of symbolic, iconic and indexical representations through differentiated visual aids promotes inclusive access to the learning of geometry. These findings further support the contention that representational coordination is not only a cognitive process but also a pedagogical strategy that enhances flexibility, comprehension and equitable participation for learners of mathematics (Alex & Mammen, 2018).

5.4.2 Methodological implications

The qualitative nature of the research methodology in this study has highlighted on the experiences of educators and learners regarding the use of visual aids in teaching geometry. The research has captured at a nuanced level the patterns that take place in teachers' instructional practices and learners' engagement through the semi-structured interviews and classroom observations. Such detail would not have been available through quantitative measures alone. For example, the observational data showed marked variations in pedagogical practice. In support of this, it should be noted that Participant 2 used systematic manipulation of 2D and 3D models to scaffold understanding, while Participant 6 integrated real-life examples and digital visuals to engage advanced learners. This was a strategy that illustrated how teachers differentiate the purpose of visual aids to respond to the cognitive diversity of learners. These results signal the value of qualitative methodology in uncovering context-dependent teaching strategies and learner responses, in line with Duval's semiotic framework, which posits representational flexibility in learning as critical (Duval, 1995, 2003, 2017). In addition, the interviews allowed for articulation by teachers of constraints imposed by resource inequity, particularly in under-resourced schools, thereby providing emic perspective enhancement of ecological validity. This supports Smith and Cekiso (2020) in their contention that qualitative approaches are important in shedding light on socio-pedagogical realities framing mathematics education in South African classrooms. Mixed-methods designs could also further this through quantification of the differences in academic achievement due to the use of visual aids, complementing the qualitative depth of this study with broader generalisability.

5.4.3 Pedagogical implications

Educators' ability to align visual aids with learning objectives was critical to their success in enhancing geometry instruction (Chikiwa & Ludwig, 2023; Smith & Cekiso, 2020). Integrating visual aids into hands-on activities and encouraging active learner participation were identified as strategies for promoting engagement and comprehension. Addressing resource disparities in underprivileged schools remained a priority to ensure equitable access to quality education (Amnesty International, 2021). This study highlighted the need for professional development programmes to equip educators with the skills to select, design and implement visual aids effectively (Kennedy, 2016).

5.5 CONCLUSIONS

5.5.1 Conclusions from the literature

The literature established that visual aids are indispensable in teaching geometry due to their ability to make abstract concepts tangible and accessible. Research consistently demonstrated that these tools improved spatial reasoning, engagement and academic performance (Alex & Mammen, 2018; Mabena et al., 2021). However, challenges such as improper use, over-reliance and resource constraints highlighted the need for educator training and thoughtful implementation (Smith & Cekiso, 2020; Chikiwa & Ludwig, 2023).

5.5.2 Conclusions from the methodology

The interpretive phenomenological approach adopted in this study provided nuanced insights into the lived experiences of learners and educators (Shabiralyani et al., 2015). This approach underscored the complexity of integrating visual aids into geometry instruction and the necessity of considering contextual factors such as educator readiness and resource availability (Dimmel & Herbst, 2015). The findings emphasised the importance of qualitative methods in capturing the intricate dynamics of teaching and learning. This study affirmed that visual aids are transformative tools in geometry education when used strategically which suggests the need for further research and practical interventions to optimise their impact.

5.6 LIMITATIONS OF THE STUDY

The qualitative nature of this research study and contextuality place severe limitations on its ability to provide broad generalisations. Also, the nature of semi-structured interviews and classroom observations, coupled with its small number of school representations, may limit generalisations across diverse settings of teaching practices, learner needs and resource availability in regions other than the studied context. Resource constraints, especially in disadvantaged schools, included a lack of access to quality visual aids, which could have impacted the findings of this study. Another limitation involves the biases of the participants, as the interviews rely on self-reported data that may produce subjective interpretations rather than objective measures of effectiveness. Moreover, the research did not include quantitative measures of learners' academic performance, which would have given stronger evidence on the effectiveness of visual aids. Finally, this study lacks longitudinal data to assess the long-term effects of visual aids on learning outcomes, and such limitations should be avoided in future research.

5.7 RECOMMENDATIONS

To improve the teaching of geometry using visual aids in mathematics classrooms, the recommendations must address the realities of under-resourced schools and the socio-economic challenges the schools face. Grade 7 educators should adopt a creative and resourceful approach by leveraging locally available materials to create improvised visual aids. For example, cardboard, recycled materials and simple hand-drawn diagrams can serve as effective tools to demonstrate geometric principles. Educators should actively integrate such visual aids into lesson plans, ensuring alignment with learning objectives while tailoring them to suit diverse learner abilities. For weaker learners, simplified and concrete representations such as handmade 3D models, should be prioritised; while more complex tasks can be introduced for advanced learners. Professional development workshops, tailored to the South African context, should train educators to maximise the use of improvised and low-cost materials while incorporating culturally relevant examples to make geometry relatable to learners' environments.

Schools should prioritise creating low-cost, school-based resource libraries where visual aids can be shared among educators. These libraries could include basic geometry kits, charts and models, sourced from donations, partnerships or community initiatives. Principals and school management teams (SMTs) should actively seek collaborations with local businesses, non-governmental organisations (NGOs) and community organisations to secure funding or material support for purchasing basic geometry teaching resources. Furthermore, schools should encourage peer learning among educators through regular meetings or informal networks to share innovative strategies for teaching geometry with limited resources. Schools with access to technology should consider pooling resources within their districts to enable rotational use of digital tools such as projectors and software which helps to ensure broader access across schools.

The South African government must take decisive steps to address the disparities in educational resources. A dedicated budget for under-resourced schools should prioritise the provision of essential visual aids such as geometry kits, projectors and training for educators. The government should also develop a centralised repository of open-access educational resources including printable diagrams, lesson plans and training videos, tailored for schools with limited resources. These resources should be culturally relevant and aligned with the curriculum. Furthermore, mobile education units equipped with digital tools and geometry resources could be introduced in rural areas to provide periodic access to quality teaching aids. Policymakers should establish targeted professional development programmes for educators in underprivileged schools, focusing on using visual aids effectively in resource-constrained settings.

Community and private-sector involvement are critical in bridging resource gaps. Local businesses and organisations should be encouraged to sponsor educational materials or contribute to building resource libraries for schools in their communities. Non-governmental organizations (NGOs) and education technology companies can support schools by providing low-cost or free digital geometry tools and training programmes tailored to underprivileged schools. Furthermore, parents and community members can be involved in creating low-cost visual aids such as hand-crafted 3D models, leveraging local skills and materials.

Nonetheless, these recommendations underscore concrete and tailored approaches for the varied educational environment in South Africa. Educators should prioritise creativity and inclusiveness when using visual aids; while schools, governments and communities must come together to support schools to address the issue of unequal access to resources. Furthermore, through combining equity and innovation, these actions can greatly enhance the instruction and comprehension of geometry in South Africa, guaranteeing equal access to high-quality mathematics education for educators of all socio-economic statuses.

5.8 RECOMMENDATIONS FOR FURTHER STUDY

The following recommendations are made for future research:

- An experimental or quasi-experimental study could examine the impact of visual aids on learners in under-resourced South African schools, focusing on low-cost and improvised tools.
- A design-based or case study could explore the use of affordable technologies such as mobile apps or open-source software, as well as culturally adapted visual aids to improve engagement and understanding.
- A longitudinal or programme evaluation study could assess the effectiveness of teacher professional development and the long-term impact of visual aids on learners' geometry skills.
- A comparative or mixed-methods study could analyse traditional versus digital tools and their role in addressing language barriers in multilingual classrooms.
- A participatory action research or policy analysis study could explore the role of parents and communities in creating visual aids and strategies for fair resource distribution through policy and partnerships.

These areas can provide actionable insights into reducing educational disparities and improving geometry learning outcomes.

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APPENDICES

APPENDIX A: RESEARCH ETHICS CLEARANCE CERTIFICATE

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2024/02/14

Ref: **2024/02/14/50382969/51/AM**
Name: Mr R Sookraj
Student No.:50382969

Dear Mr R Sookraj

Decision: Ethics Approval from 2024/02/14 to 2027/02/14

Researcher(s): Name: Mr R Sookraj
E-mail address: Rivone.sookraj@gmail.com
Telephone: 083 446 7460

Supervisor(s): Name: Dr. M.M. Masilo
E-mail address: masilmm@mylife.unisa.ac.za
Telephone: 012 429 6154

Title of research:

Exploring the use of visual aids in teaching Grade 7 Geometry towards the enhancement of learners' learning experience

Qualification: MEd Mathematics Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2024/02/14 to 2027/02/14.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2024/02/14 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.

Open Rubric

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3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2027/02/14**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

Note:

The reference number **2024/02/14/50382969/51/AM** *should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,

Prof AT Motlhabane
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APPENDIX B: APPROVAL TO CONDUCT RESEARCH FROM KWA-ZULU NATAL DEPARTMENT OF EDUCATION

KWAZULU-NATAL PROVINCE
EDUCATION
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE HEAD OF DEPARTMENT

Private Bag X 9137, PIETERMARITZBURG, 3200
Anton Lembede Building, 247 Burger Street, Pietermaritzburg, 3201
Email: buyi.ntuli@kzndoe.gov.za **Tel:** 033 392 1051
Ref No.: 2/4/8/170
Enquiries: Mrs B. T. Ntuli

Mr Rivone Sookraj
Unit 42 San Michel Complex
57Bohmer Road
NEW GERMAN
3610

Dear Mr Sookraj

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"EXPLORING THE USE OF VISUAL AIDS BY GRADE 7 TEACHERS FOR ENHANCING LEARNERS' LEARNING EXPERIECES IN GEOMETRY:",** in the KwaZulu-Natal Department of Education institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from **22nd April 2024 to 31st August 2026**.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Mrs Buyi Ntuli at the contact numbers above.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

Mr G.N. Ngcobo
Head of Department: Education
Date: 22 April 2024

GROWING KWAZULU-NATAL TOGETHER

APPENDIX C: PERMISSION LETTER TO PRINCIPALS

Rivone Sookraj

[Physical Address]

[E-mail Address]

[Phone number]

[Name of School]

[Name of Principal]

[Address of School]

[Date]

Dear Sir/Madam,

Re: Permission to conduct research at [Name of school].

My name is Rivone Sookraj.

I am studying for a Master of Education in Mathematics Education at UNISA. I am seeking permission to do research at your school.

Research Title: Exploring the use of visual aids in teaching Grade 7 geometry to enhance the learning experience.

Research Aim: To explore the teaching of Geometry using visual aids on Grade 7 learners' learning experience.

The research will entail collecting data from Grade 7 mathematics teachers at your school. I will invite teachers from your school to participate in this study. If they agree, they will be interviewed (for approximately 30 minutes) and will be observed while they teach mathematics lessons. Since there will be learners present in the classroom during the teacher's lesson, consent and assent forms will be given to the learners and parents/guardians to sign respectively.

Participants will be asked to give their written or verbal consent before the research begins. Their responses will be treated confidentially and identities (their names and the name of the school) will be anonymous unless otherwise expressly indicated. Individual privacy will be maintained in all published and written data resulting from the study.

Reports containing the results of the study will be emailed to participants.

The research participants will not be disadvantaged in any way. They will be reassured that they can withdraw their permission at any time during this study without any penalty. There are no foreseeable risks in participating in this study. The participants will not be paid for this study.

I therefore request permission in writing to conduct my research at your school. The permission letter should be on your school's letterhead, signed and dated and specifically referring to myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response as soon as is convenient.

Yours sincerely,

Rivone Sookraj

APPENDIX D: EDUCATOR CONSENT LETTER

EXPLORING THE USE OF VISUAL AIDS BY GRADE 7 EDUCATORS FOR ENHANCING LEARNERS' LEARNING EXPERIENCES IN geometry

The aim of this research is to explore the use of visual aids by Grade 7 teachers for enhancing learners' learning experiences in geometry.

You are invited to participate in an interview and classroom observation for this study topic mentioned above. This research dissertation is being conducted by Rivone Sookraj, MEd learner at UNISA (University of South Africa). It should take approximately 30 minutes to complete to complete the interview portion and one geometry classroom observation session.

PARTICIPATION

Your participation in this survey is voluntary. You may refuse to take part in the research or exit the from participating in this study at any time without penalty. You are free to decline to answer any question you do not wish to answer for any reason.

BENEFITS

You will receive no direct benefits from participating in this research study. However, your responses may help us learn more about the impact of using visual aids to enhance the learning experience for Grade 7 geometry learners.

RISKS

There are no foreseeable risks involved in participating in this study other than those encountered in day-to-day life.

CONFIDENTIALITY AND ANONYMITY

All data collected will be kept safe in a password protected computer. Also, no personal information or details will be collected during this study so as to preserve anonymity of the participants.

CONTACT

If you have questions at any time about this study or the procedures, you may contact me Rivone Sookraj via phone at +27 83 446 7460 or via e-mail at rivone.sookraj@gmail.com.

Participant signature	**Date**
________________	______________

APPENDIX E: PARENT CONSENT LETTER

Dear Parent

Your child is invited to participate in a study entitled: Exploring the use of visual aids by Grade 7 teachers for enhancing learners' learning experiences in geometry.

I am undertaking this study as part of my Master's research at the UNISA. The purpose of this study is to explore how the use of visual aids in teaching practices in geometry enhance the learning experience of learners in Grade 7 geometry lessons. This study will benefit the school district, learners and educational community by improving their overall mathematics performance. I am asking permission to include your child in this study because their participation will contribute valuable insights into the use of visual aids for enhancing the learning experience of Grade 7 learners in geometry. I expect to have approximately 450 other children participating in this study.

If you allow your child to participate, I will request him/her to:

Take part in a lesson observation. Your child will only be required to be a part of the class when their mathematics teacher is teaching a geometry lesson using visual aids as resources.

Any information that is obtained in connection with this study and can be identified with your child will remain confidential and will only be disclosed with your permission. His/her responses will not be linked to his/her name or your name or the school's name in any written or verbal report based on this study. Such a report will be used for research purposes only.

There are no foreseeable risks to your child by participating in this study. Your child will receive no direct benefit from participating in this study; however, the possible benefits to education are the improvement of results in Grade 7 geometry as well as the improvement of educational practices in Grade 7 mathematics. Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly, you can agree to allow your child to be in this study now and change your mind later without any penalty.

This study will take place during regular classroom activities with the prior approval of the school and your child's teacher. However, if you do not want your child to participate, they will be moved to another Grade 7 classroom in their school whereby they will be taught as normal without the presence of the researcher.

In addition to your permission, your child must agree to participate in this study, and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in this study, he or she will not be included and there will be no penalty. The information gathered from this study and your child's participation in this study will be stored securely on a password locked computer in my locked office for five years after this study. Thereafter, records will be erased.

There are no risks involved in this study and there will be no reimbursement or any incentives for participation in the research.

Add your signature below to indicate that you have read the information provided above and allow your child to participate in this study. You may keep a copy of this letter.

Name of child:

Sincerely

__________________________ ____________________ _______

Parent/guardian's name (print) Parent/guardian's signature: Date:

__________________________ ____________________ _______

Researcher's name (print) Researcher's signature Date:

APPENDIX F: LEARNER ASSENT LETTER

Dear Learner **Date:**

My name is Teacher Rivone and would like to ask you if I can come and watch you learn mathematics when your teacher uses exciting items to teach you geometry. I am trying to learn more about how children learn geometry when their teachers use objects during mathematics lessons.

If you say YES to do this, I will come and watch you when you are with your teacher is teaching you geometry using different items. I will not ask to you to do anything that may hurt you or that you don't want to do.

I will also ask your parents if you can take part. If you do not want to take part, it will also be fine with me. Remember, you can say yes or you can say no and no one will be upset if you don't want to take part or even if you change your mind later and want to stop. You can ask any questions that you have now. If you have a question later that you didn't think of now, ask me next time I visit your school.

Please speak to mommy or daddy about taking part before you sign this letter. Signing your name at the bottom means that you agree to be in this study. A copy of this letter will be given to your parents.

Regards,

Teacher Rivone

Your Name	**Yes, I will take part** 	**No, I don't want to take part** 
Name of the researcher		
Date		
Witness		

APPENDIX G: CLASSROOM OBSERVATION SCHEDULE

1. Basic Information

Date and Time: Record the date and time of the observation.

Class Details: Specify the class name, Grade and subject.

2. Introduction

Aim: This study aims to explore the teaching of geometry using visual aids on Grade 7 learners' learning experiences.

Focus Areas: Visual aids, selection criterion, response of learners, quality of visual aids, general classroom practices on the use of visual aids and the development of the learning experience.

3. Classroom Environment

Availability of visual aids

Learner accessibility of resources

Type of visual aids used: Observe the variety of visual aids employed during geometry lesson.

Assessed impact: Indication of relevancy (connection to the subject being taught), clarity (not causing misunderstanding), explanatory effect (providing facts to aid the understanding of learners), integration (the level to which visual aids are seamlessly blending and coordinating with the lesson presentation) and interest (ability to garner interest in learning).

Relevancy:
Clarity:
Explanatory effect:
Integration:
Interest:

4. Teachers' Facilitation Strategies Utilising Visual Aids

5. Learner Engagement

Engagement Strategies: Note any strategies used to engage learners from the beginning.

6. Closure and Summary

Lesson Closure: Evaluate how the lesson is concluded.

Summary of Key Points: Summarise the key observations and takeaways in the context of how visuals aids facilitate understanding of geometry.

APPENDIX H: INTERVIEW SCHEDULE GUIDE

1. How long have you been teaching Grade 7 mathematics?
2. What is your highest educational qualification?
3. Based on your understanding may you please describe what visual aids are?
4. Do you use visual aids when teaching Grade 7 geometry? Explain your answer.
5. Did you receive any formal training or similar on how to use visual aids for Grade 7 geometry? Explain how this has influenced your ability to use appropriately use visual aid during Grade 7 geometry lessons.
6. May you please describe the criterion that you use to select the appropriate visual aids to meet learning objectives.
7. What has prompted you to use that criterion? Elaborate in detail.
8. In your experience, do you think the quality of the visual aids has an influence on the learning experience of the Grade 7 geometry learners? Explain your answer.
9. Based on your experience, may you please describe the impact of using visual aids in enhancing the learning experience of Grade 7 learners?
10. Do you have any other points you wish to address, or any comment related to this topic?

APPENDIX I: OBSERVATION EVIDENCE (VIGNETTES)

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<td>Participant 1

Vignette 1

Types of angles</td>
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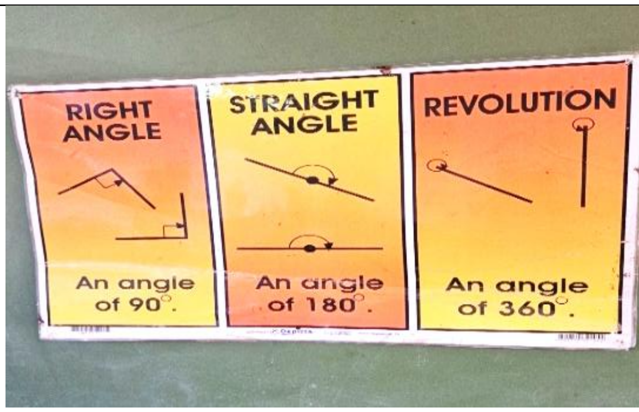
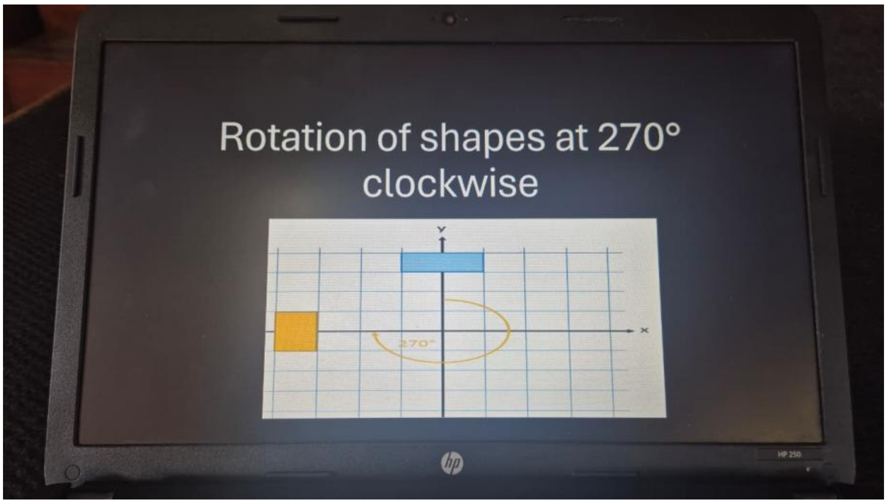


Vignette 1.1 (Chart)



Vignette 1.2 Animated slide presentation

Vignette 1.3 Hinge stick model
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2D net and 3D objects made by learners</td>
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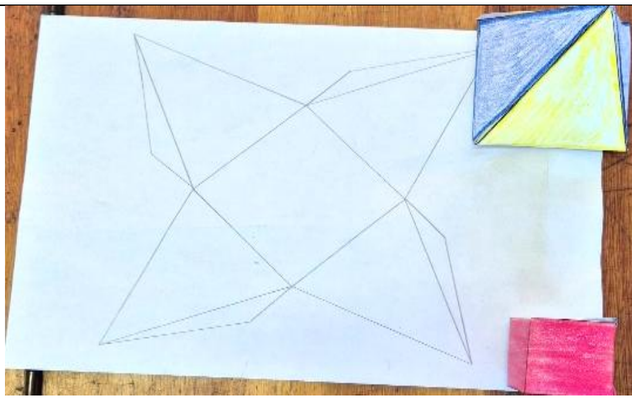
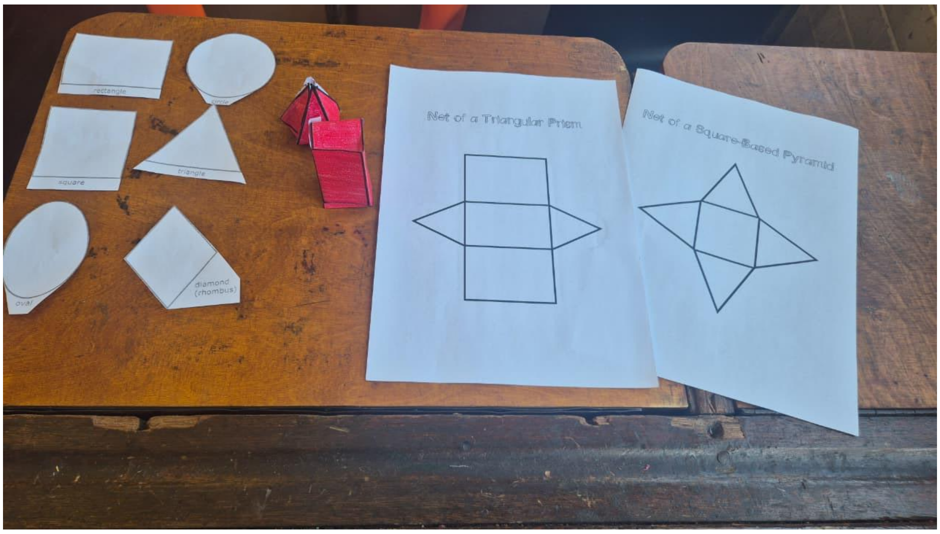


Vignette 2.1



Vignette 2.2
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<td>Participant 3</td>
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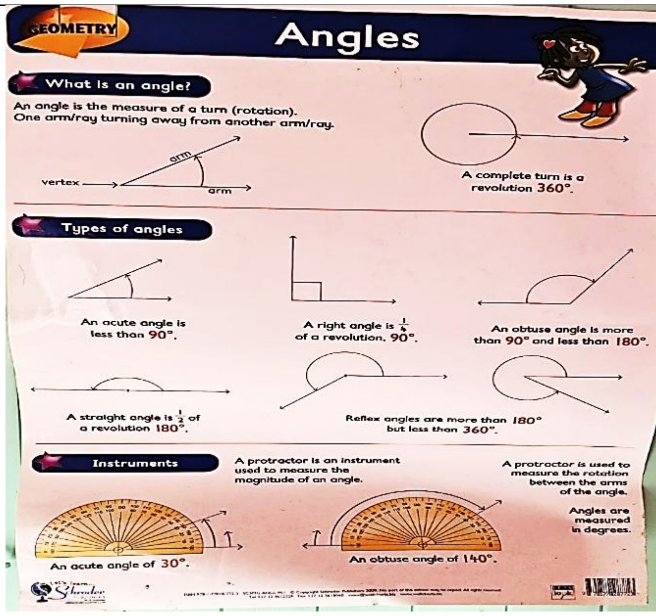

Vignette 3.1
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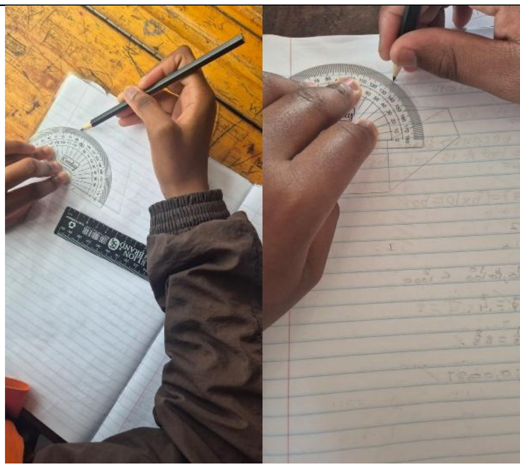
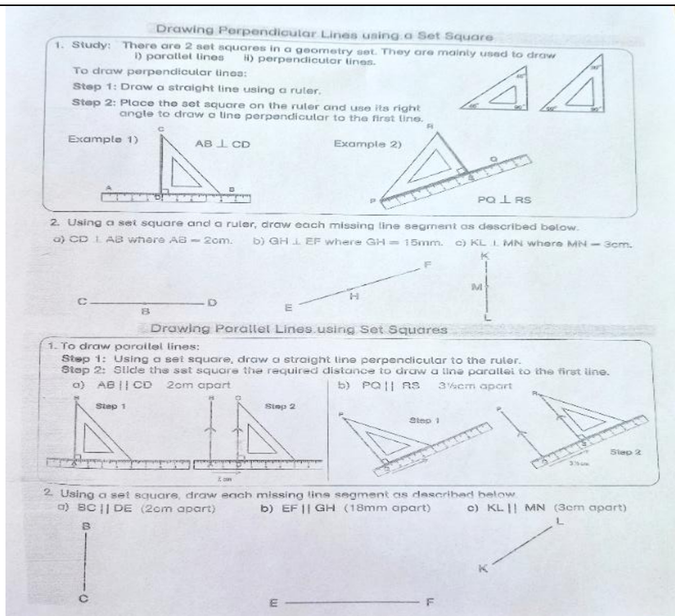
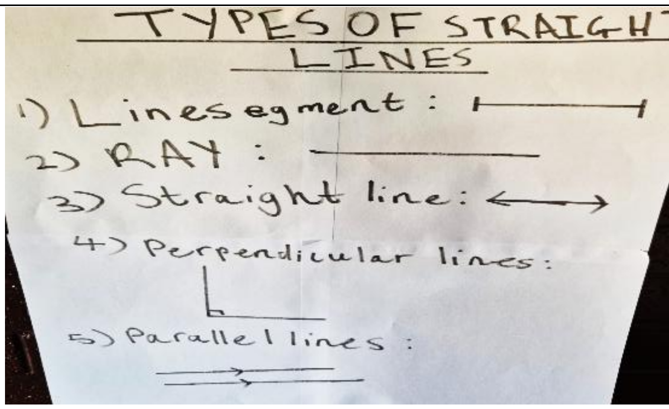
<tr><td></td><td>
Vignette 3.2</td></tr>
<tr><td>Participant 4

Worksheet</td><td>
Drawing Perpendicular Lines using a Set Square
1. Study: There are 2 set squares in a geometry set. They are mainly used to draw i) parallel lines ii) perpendicular lines.
To draw perpendicular lines:
Step 1: Draw a straight line using a ruler.
Step 2: Place the set square on the ruler and use its right angle to draw a line perpendicular to the first line.
Example 1) AB ⊥ CD
Example 2) PQ ⊥ RS
2. Using a set square and a ruler, draw each missing line segment as described below.
a) CD ⊥ AB where AB = 2cm. b) GH ⊥ EF where GH = 15mm. c) KL ⊥ MN where MN = 3cm.
Drawing Parallel Lines using Set Squares
1. To draw parallel lines:
Step 1: Using a set square, draw a straight line perpendicular to the ruler.
Step 2: Slide the set square the required distance to draw a line parallel to the first line.
a) AB || CD 2cm apart b) PQ || RS 3½cm apart
2. Using a set square, draw each missing line segment as described below.
a) BC || DE (2cm apart) b) EF || GH (18mm apart) c) KL || MN (3cm apart)
Vignette 4 - Worksheet</td></tr>
<tr><td>Participant 5</td><td>

Vignette 5 - Chart</td></tr>
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Vignette 6 Visual aid Participant 6